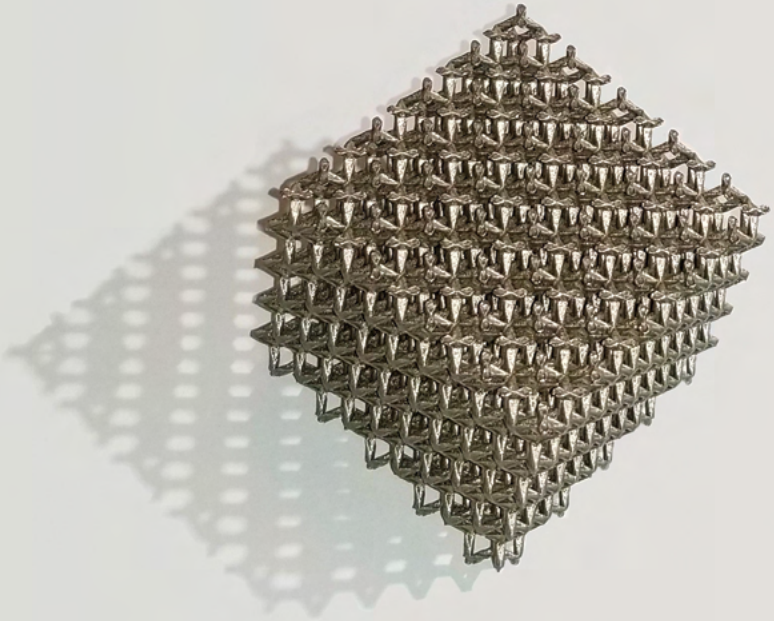
Southwest Research Institute®

Annual Report 2018



NEW HORIZONS' CLOSE FLYBY OF ULTIMA THULE

As 2018 came to a close, NASA's New Horizons spacecraft achieved its latest triumph: flying within 2,200 miles of 2014 MU69, nicknamed Ultima Thule. This distant, icy object orbits in the vast "third zone" of our solar system, beyond the rocky planets and gas giants. In 2015, New Horizons gave the world the first detailed images of Pluto and its moons. The latest mission milestone ushers in a new era of exploration in the Kuiper Belt, a region of primordial objects critical to understanding the origin of the solar system.

SwRI leads the New Horizons mission and, in addition, manages the science team, three instrument investigations, payload operations and encounter science planning. The mission is credited again with the farthest exploration of any world in history — this time 4 billion miles from Earth, a billion miles farther than the previous record set at Pluto.

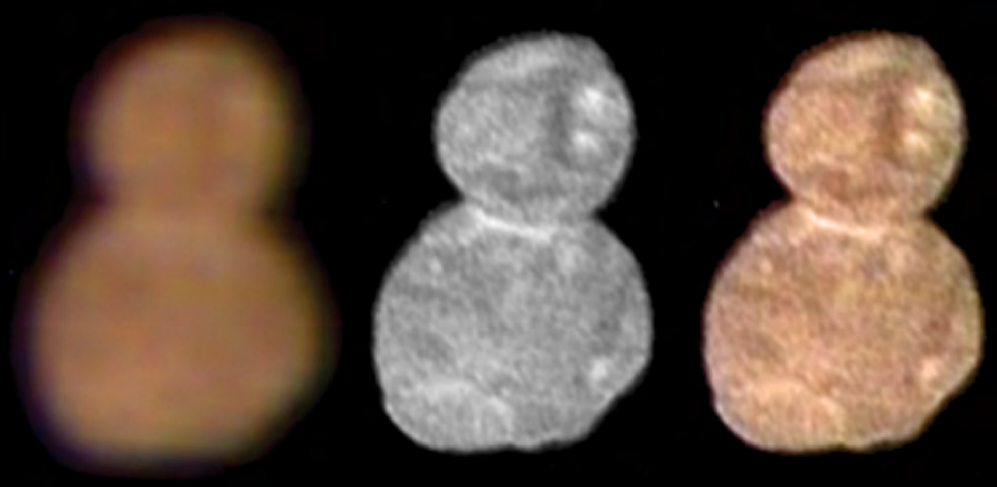
The spacecraft's Ultima Thule flyby was an event 13 years in the making. New Horizons launched in 2006 and will continue its exploration of the Kuiper Belt until at least 2021 — and may ultimately include additional encounters.

The data yielded from the Ultima Thule flyby is already offering fascinating results. The object is the first Kuiper Belt contact binary ever visited, with two lobes reminiscent of a snowman spinning end over end. Its dimensions are approximately 20 by 10 miles.

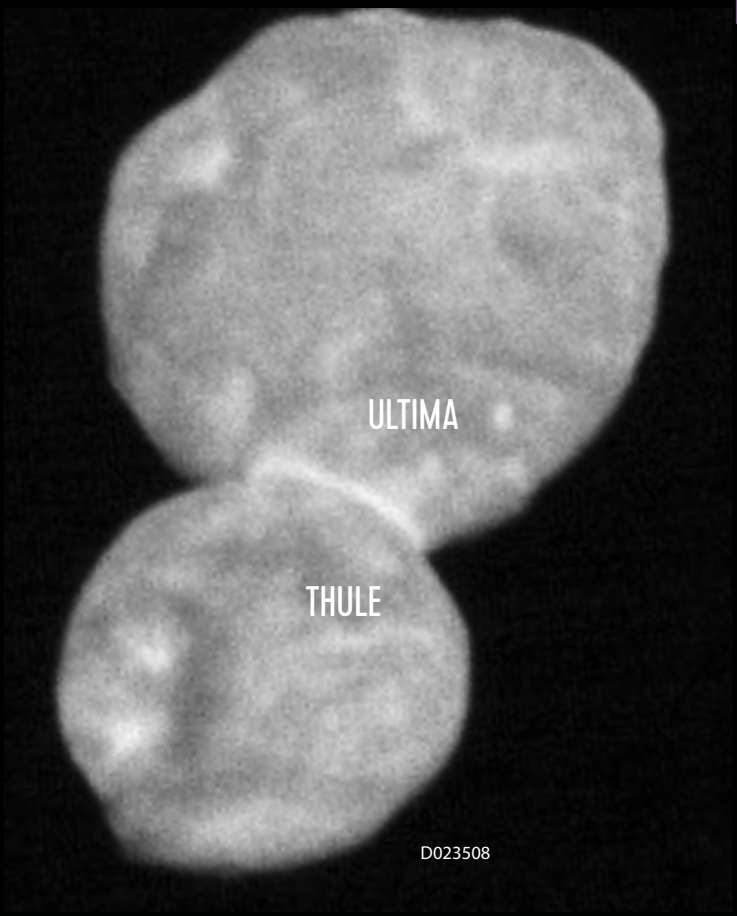
The initial analysis also shows that the object likely has no atmosphere, rings or satellites. Its color matches that of similar worlds in the Kuiper Belt, as seen by telescopes. Its two lobes, informally known as Ultima and Thule, are nearly identical in color, which matches binary systems that are not in contact with each other, but rather orbit around a shared point of gravity.

While the most distant exploration of any world to date is now history, almost all of the data analysis lies in the future. As New Horizons hurtles closer to the outer reaches of the solar system, it will take 20 months to download the remaining scientific treasures from the flyby.

D023507



This first color image of Ultima Thule, taken at a distance of 46,000 miles, highlights its reddish surface. At left is an enhanced color image taken by the spacecraft's Multispectral Visible Imaging Camera (MVIC), produced by combining the near infrared, red and blue channels. The center image taken by the Long-Range Reconnaissance Imager (LORRI) has a higher spatial resolution than MVIC. At right, the color has been overlaid onto the LORRI image to show the color uniformity of the Ultima and Thule lobes.



NEW HORIZONS' NEW RECORDS

4 BILLION MILES
FARTHEST OBJECT

2,200 MILES
CLOSEST APPROACH

-400° F
COLDEST OBJECT

1ST PRIMORDIAL CONTACT BINARY
KUIPER BELT OBJECT

LEFT: Dr. Alan Stern (center), SwRI associate vice president and New Horizons principal investigator, and SwRI President Adam L. Hamilton (background left) celebrate with the "Kuiper kids" as New Horizons buzzes past Ultima Thule. These children are friends and family of the mission team.

IMAGES COURTESY NASA/JHUAPL/SwRI/ED WHITMAN

TABLE OF CONTENTS

ABOUT THE COVER

Southwest Research Institute is developing complex components using state-of-the-art metal additive manufacturing capabilities that create both the material and the component simultaneously. A new selective laser melting machine fuses regions of fine metal powder in a layer-by-layer process to 3D print a metal component. This manufacturing technique greatly expands design options, cost-effectively fabricating complex parts with internal structures or features that are difficult, if not impossible, to produce using conventional forging, casting and machining methods. Engineers can optimize components, as illustrated by this lattice, with internal structures to tailor stiffness, reduce weight or improve thermal management.

PRESIDENT'S MESSAGE

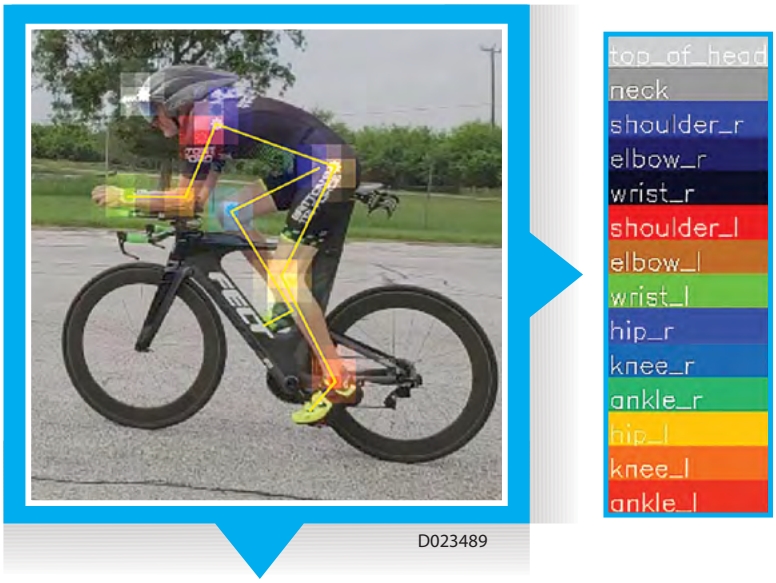
For more than 70 years, Southwest Research Institute has pushed the boundaries of scientific and engineering applications by continuing to innovate as we fulfill our mission for the benefit of our clients and all humankind. Our multidisciplinary, client-focused approach to solving critical technical challenges in environments from Deep Sea to Deep Space® has guided us through another successful year.

I am pleased to present the 2018 Annual Report, which highlights some of our accomplishments, made possible by our time-tested approach, and summarizes the Institute's improved financial performance in Fiscal Year 2018.

Our FY18 financial performance was much improved because of the hard work and dedication of our staff. Additional emphasis on enhancing our business development practices, using collaborative teams to grow into new markets and offer expanded capabilities to existing clients, and our added attention to cost controls are largely responsible for the notable fiscal improvements. In addition, the relatively healthy macroeconomic conditions and the recovery of the oil and gas marketplace also contributed to our financial success. The combination of staff efforts and these favorable economic conditions allowed us to grow our research revenue by more than 10 percent to $583.7 million and produce a net income (net assets at the end of the year) of $38 million.

While our financial performance is important and financial success is paramount to our sustainability, our pride in the Institute is tied to the programmatic success and technical contributions that we make to the national and international communities. Our technical staff sought collaborative research opportunities, both within the Institute and with other organizations, as we grew our technical programs in FY18. This year, we were awarded several U.S. government contract mechanisms including an indefinite delivery/indefinite quantity contract spanning chemical, biological, radiological and nuclear defense laboratory projects.

Also in 2018, we broke ground on a novel pilot-scale supercritical carbon dioxide (sCO_2) electric power generation plant to demonstrate high efficiency, lower emissions, and lower-cost benefits of this new technology. We extended a 20-year agreement with the Central Research Institute of Electric Power Industry in Tokyo, Japan, to provide technology, research and development services to the Japanese power industry. These include evaluating fire hazards at nuclear facilities; creating advanced technology for safe and efficient electric power generation, storage and distribution; developing advanced combustion cycles; and designing smart grid technology.



Using internal research funding, a multidisciplinary team developed human performance expertise. One result was a patent-pending, low-cost "markerless" motion capture system that uses a biomechanical musculoskeletal model fused with deep learning algorithms to characterize physical motion. We are now positioned as one of the leaders in this field, working with professional sports teams and the tactical athlete community.

INTERNAL RESEARCH

Our internal research and development program allows SwRI engineers and scientists the freedom to explore innovative, unproven concepts. The program often invests in technology our clients will need in the future. It also expands into completely new fields where collaborations among our diverse staff result in novel approaches or technology. In 2018, SwRI initiated 84 new projects and spent more than $7 million on internal research.

These efforts included focused projects, funded through the Metals Additive Kickoff Emphasizing Research Synergies (MAKERS) initiative, designed to advance SwRI's collective understanding of emerging additive manufacturing technologies.

Meanwhile, we joined the University of Texas at San Antonio in a project to develop a 3D-printed implant to deliver various therapeutics to treat diseases, and another to develop DNA-based tracers to characterize the recharge and flow patterns in the Edwards Aquifer, San Antonio's source of drinking water.

We invested in a number of infrastructure projects to better support our clients and enable our researchers to expand their expertise and offer new capabilities. Engineers in our new Collaborative Robotics Laboratory used deep-learning algorithms, perception technologies and advanced path planning tools to develop collaborative robots, called "cobots," that work safely alongside humans to perform multiple complex tasks.

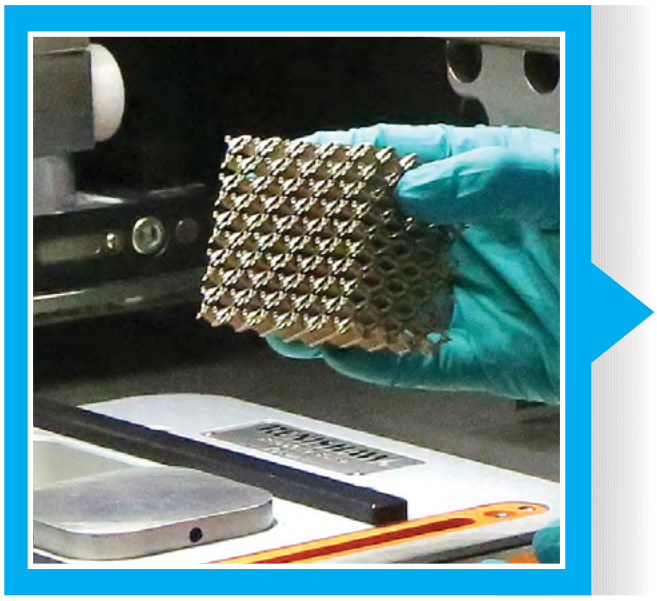
We opened our Energy Storage Technology Center® laboratory, which gives us more capacity and flexibility to perform leading-edge research on battery performance and characterize next-generation energy storage and enhanced vehicle electrification. To meet international health concerns over solid particle emissions, our fully accredited particle emissions laboratory was qualified to calibrate equipment to ISO/IEC 17025 standards.

The Institute invested nearly $7 million in internally funded research to advance our technology base and allow technical staff to explore innovative concepts and extend their reach. Many of these projects are detailed throughout this report.

We take pride in being good corporate neighbors. Staff members mentor students in science, technology, engineering and math (STEM); serve as judges at collegiate and high school STEM competitions; and speak at numerous community outreach activities. Meanwhile, they advance science and technology through peer-reviewed papers, presentations, patents and other activities.

Many SwRI staff members sit on boards and committees of industry and professional groups seeking to set industry standards and advance scientific innovation. Others are active in the local community supporting the food bank, delivering meals to seniors, contributing to United Way agencies, and much more. This year, Forbes Magazine named the Institute one of the 500 "America's Best Workplaces" among midsize employers with 1,000 to 5,000 employees. In addition, the Institute continues to be a major economic contributor in San Antonio, contributing more than $1 billion to the local economy.

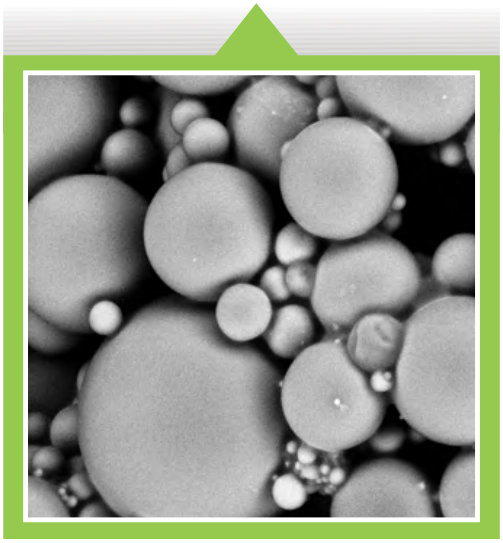
While the coming year brings with it new challenges, a healthy backlog of contracts will likely make FY19 another successful year with proposals and follow-on research pointing to even more new opportunities. We remain committed to being the first choice for clients seeking solutions for their most complex problems. I am grateful to our Board of Directors for their dedication, to our Board of Advisory Trustees for their valued advice, and to the technical and administrative staff for their hard work and support. Together we will ensure that our clients receive the highest quality scientific and technical services in 2019 and beyond.



D022894

Through the MAKERS program, SwRI staff are developing new techniques to create complex parts using state-of-the-art metal additive manufacturing methods. Engineers have optimized components, as illustrated by this lattice, with internal structures to tailor stiffness, reduce weight or improve thermal management.

With internal research funding, SwRI developed a novel emulsion-based microencapsulation process using natural materials. This environmentally friendly process could replace synthetic and formaldehyde-based formulations used in products ranging from fragrances to paints and coatings.



D023498

MILESTONES 2018

PRESENTATIONS GIVEN **680**

667 PAPERS PUBLISHED

14 CONSORTIA

D023499

In 2018, SwRI managed 14 multi-client programs designed to allow organizations to pool their R&D dollars for pre-competitive research. For example, the Permian Basin joint industry program is characterizing the distribution, mechanisms and orientations of faults and fractures related to tectonic events. Results help oil and gas industry members develop successful drilling and production strategies.

LEADERSHIP

Imad Khalek – Chair of SAE's Exhaust Aftertreatment and Emissions Committee
Steve Dellenback – Board Secretary for the Intelligent Transportation Society of America
Alan Stern – National Science Board Member
Michael Ladika – Board President for the National Advanced Mobility Consortium
James Walker – Treasurer of the International Ballistics Society

AWARDS

Amy McCleney – New Member Impact Award from the American Petroleum Institute
Gordon Johnson – 2018 John Rinehart Award from the European Association for the Dynamic Behavior of Materials
Cary Henry & Chris Sharp – 2017 SAE John Johnson Award for Research in Diesel Engines

HONORS

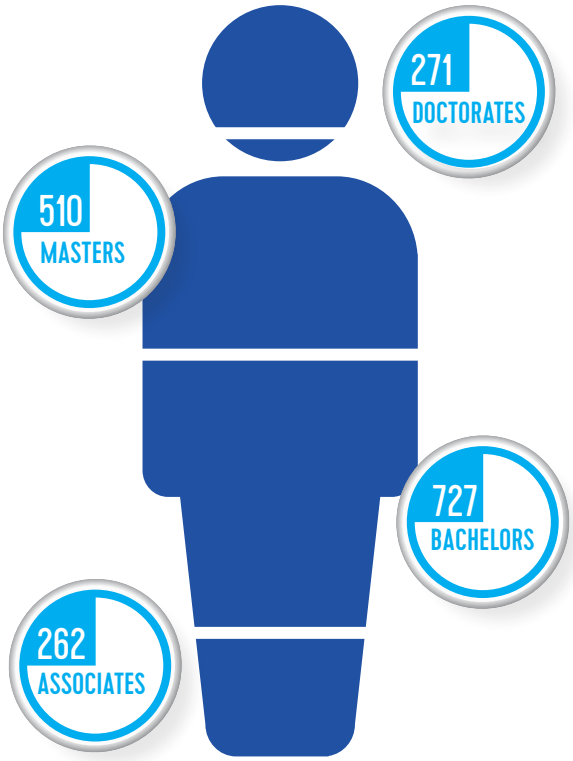
Kevin Hoag – Elected an SAE Fellow
Barron Bichon – Named an Associate Fellow of American Institute of Aeronautics and Astronautics
Finley Hicks – Named Dixie Crow Test & Evaluation Engineer of 2018, Association of Old Crows
Peter Lee – Elected an Institution of Mechanical Engineers Fellow
Terry Alger – Named a Distinguished Mechanical Engineer by The University of Texas at Austin Cockrell School of Engineering

R&D 100 FINALIST

SwRI's Direct Electronic Vehicle Controller (DEVCon™) with auto-shifter precisely measures vehicle fuel economy and carbon dioxide (CO_2) output. Automotive engineers developed DEVCon using an electronic interface that delivers repeatable, precise and cost-effective simulations of human drive cycles in a test cell.

D022879

2,602 EMPLOYEES

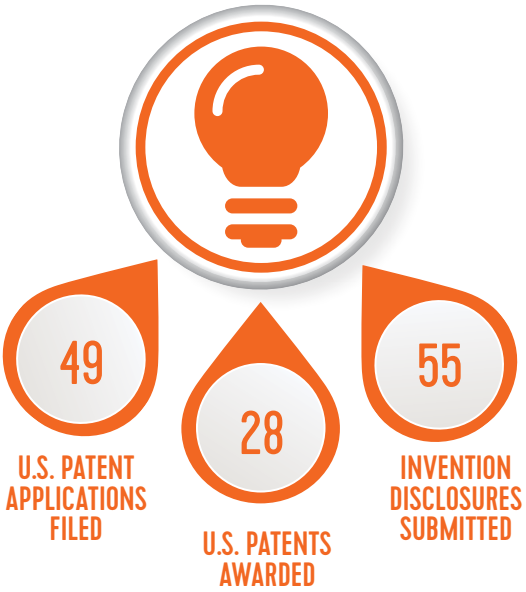


NEW LABORATORY

In 2018, we launched a Collaborative Robotics Laboratory to deliver advanced automation technology to the heavy industry and manufacturing sectors. The facility features collaborative robots, "cobots" that safely work side-by-side with humans, in a flexible lab setting where engineers develop agile, mobile and automated capabilities.

D023231

PATENTS



SAFETY

APPLIED PHYSICS

- Digital & Analog Electronics
- RF Systems
- Electromechanical Systems
- Micro-Power Circuitry
- Sensors
- Microbiology
- Virology
- Cell Biology
- Metamaterials
- Nanomaterials
- Lasers, Optics & Electro-Optics
- Acoustics & Ultrasonics
- Biometric Systems
- Nonlethal Weapons
- MEMS
- Robotic Vehicle Evaluations
- Failure Analysis
- Rapid Prototyping
- Miniaturization Technologies
- Turbine Engine Tests & Diagnostics
- Condition Based Maintenance
- Flight Controls
- Gunship Controls & Simulation
- Automated Test Systems
- Unmanned Aerial Vehicles

Customizable control system software monitors sensors and captures data for this T700 test cell SwRI developed, installed and commissioned for the Australian Department of Defence.

Southwest Research Institute pushes the boundaries of engineering and physics to create advanced technologies and systems that meet our clients' challenging demands. Our diverse staff and world-class expertise create innovative, cost-effective approaches that solve complex problems, particularly for national security applications.

SwRI continues to develop access-denial technologies, using nonlethal deterrent systems to prevent or delay access by people or vehicles. In 2018, we evaluated how an aversive system would dissuade intruders from entering an unprotected facility. Test subjects completed a custom obstacle course using escalation-of-force techniques ranging from sound effects to pyrotechnics. The team evaluated test subject performance to identify the most effective deterrent systems to protect assets.

In related research, SwRI engineers are developing a smaller, more compact version of its Long Range Ocular Interrupter (LROI). This nonlethal technology is designed to assess, slow or thwart potential threats, such as an unidentified boat approaching a naval vessel. LROI uses a high-intensity eye-safe laser to deliver a dazzling, brilliant beam to fend off intruders without causing harm.

For the U.S. Air Force, SwRI is supporting the development of a roll-on, roll-off palletized weapons system to convert most medium- to heavy-lift transport aircraft into highly accurate gunships. Our engineers are supporting accuracy objectives, developing firing angle software, recommending gun mount designs and executing gun mount structural analyses. In 2019, SwRI will conduct data analyses during field testing to assess system performance and recommend improvements.

For our allies, SwRI engineers developed a custom engine dynamometer test stand to support the Royal Australian Navy's MH-60R Seahawk helicopter. We designed, manufactured and integrated maintenance equipment for T700 engines, including mass air flow measurement and engine start systems as well as monitoring and control technology. The system was completed, delivered and integrated in late 2018.

Closer to home, the Corpus Christi Army Depot (CCAD) performs maintenance on the T55 family of turboshaft engines that power the CH-47 Chinook and MH-47 helicopters. Over the last year, SwRI reverse engineered and redesigned the engine control console for one of CCAD's test cells to replace unreliable and unsupportable technology. We updated test cell documentation and integrated and evaluated the newly designed console.

SwRI is working for a commercial client to develop and implement a Condition Based Maintenance (CBM) plan for NASA's Johnson Space Center (JSC). CBM can drastically reduce operating costs and increase the safety of equipment requiring periodic maintenance. SwRI engineers have developed a five-year master maintenance plan to ensure the International Space Station's Mission Control Center at JSC operates reliably and continuously. The plan ranks assets to implement CBM for the most critical equipment and for the most time-consuming maintenance. Assets under CBM are already showing a return on investment, reducing the time spent troubleshooting equipment.

SwRI continues to conduct research in other areas, including acoustics, additive manufacturing and microbiology.

For more information visit **applied-physics.swri.org** or contact Vice President Ken Bennett at 210.522.5242 or kenneth.bennett@swri.org.

In access-denial research, SwRI evaluated how nonlethal deterrents, such as pyrotechnics, affect a test subject's ability to maneuver a large, heavy object along a specific path.

D022804

To improve reliability and maintainability, SwRI is working for a commercial client to implement Condition Based Maintenance for equipment supporting the International Space Station Mission Control Center at NASA's Johnson Space Center.

D023506

AUTOMOTIVE ENGINEERING

- Gasoline & Diesel Engine Lubricant Evaluations
- Driveline Fluids Evaluations
- Filtration Evaluations
- Fuel Performance & Qualifications
- Analytical Support Services
- Fuel Economy Evaluations
- Test Stand Design & Fabrication
- Fuel & Lubricant Surveys, Sampling & Analyses
- Screener Development
- Computational Fluid Dynamics
- Fire-Resistant Fuels
- Model-Based Controls
- Engine Design
- Emissions Reduction
- Transmission Design
- Natural Gas Engine Development
- Materials Compatibility
- Alternative Fuel Evaluations
- Powertrain Modeling & Controls Development
- High-Efficiency Gasoline Engine Research
- Particle Science
- Engine Development
- Generator Set & Combined Heat & Power Evaluations
- Homogeneous Charge Compression Ignition
- Hydraulic Design
- Hardware-in-the-Loop Evaluations
- Light-Duty Fuel Economy
- Dedicated EGR® Engine Development
- Hybrid Vehicle Design
- Contamination Research
- Wear Evaluations
- Vehicle Testing
- Accelerated Durability Evaluations
- Energy Storage Technologies
- Battery Evaluations
- Applied Electronic Controls
- Tribology

We push batteries to their limits and beyond in a new Energy Storage Technology Center, one of the largest state-of-the-art lithium ion battery and energy storage systems research facilities in the country.

12,000 SQUARE FEET

10 BATTERY TESTING CHAMBERS

10X MORE SPACE THAN PREVIOUS FACILITY

>40,000 BATTERIES TESTED SINCE 2010

ABOVE: SwRI's Locomotive Technology Center helps clients verify the performance of technologies designed to lower locomotive emissions. We conduct various evaluations, including a 3,000-hour California Air Resources Board verification test.

RIGHT: Wet clutch friction performance is vital for automatic transmission operations and durability. SwRI offers 12 test stands to determine automatic transmission fluid compatibility with different friction plate materials over a variety of operating conditions.

As today's transportation technology continues to advance, Southwest Research Institute remains at the forefront, developing innovative solutions for safer, cleaner and more efficient vehicles. We combine our experience developing next-generation powertrain technology with extensive fuels and lubricants expertise to address our clients' performance, efficiency and emissions challenges.

As one of the largest independent engines, fuels and lubricants research facilities in the world, we test virtually every engine oil and fluid available on the market. We expanded our Ann Arbor, Michigan, technical center with engine development test cells — including one specifically for automated vehicles. These new facilities bolster our capabilities in high-efficiency powertrain development and emissions research in the Detroit area and augment the more than 200 research dynamometers at our San Antonio headquarters.

Our new 12,000-square-foot Energy Storage Technology Center® is one of the largest state-of-the-art lithium ion battery and energy storage systems research facilities in the country. As development of tomorrow's vehicle electrification ramps up, we are positioned to expand our battery performance and characterization, lifecycle assessment, and aging, temperature and abuse testing. We offer 10 battery testing chambers that run prescribed charge/discharge cycles under extreme temperature conditions. In secure chambers, we push batteries to their limits and beyond with penetration, crush, vibration, drop, accelerated aging, fire/flammability resistance, corrosion and overcharge testing.

Powertrain components of hybrid-electric vehicles are designed to work together. We developed a high-fidelity, high-precision measuring system to study energy flow across subsystems of a plug-in hybrid electric vehicle to assess system synergy. Current U.S. Environmental Protection Agency certification procedures for hybrid vehicles lack the fidelity and precision needed for vehicle-level efficiency optimization. Because the engine, electric components, gearing ratios and power transfer devices are closely integrated and cannot operate independently, SwRI determined that optimizing electrified powertrains will require new methods and data acquisition strategies.

In 2018, our particle emissions laboratory became the only one in the world that is fully accredited by the American Association for Laboratory Accreditation for calibrating equipment to ISO/IEC 17025. Particle emissions are a major health concern around the world, and the European Union, China and India are tightening regulations from combustion sources, including automotive and aircraft engines. SwRI's particle emissions lab is certified to calibrate devices that measure surface area, mass, size, morphology, and particle number and particle sizes as small as 10 nanometers in diameter.

Future emissions and fuel economy regulations are demanding more performance from heavy-duty diesel engines. To improve efficiency, SwRI is exploring how combustion optimization can increase peak cylinder pressure and how low-viscosity lubricants can reduce friction. We also developed a dynamic bearing test rig to advance diesel engine research through the Clean High-Efficiency Diesel Engine (CHEDE-VII) consortium. As the industry's longest running diesel research consortium, CHEDE has more than two dozen client company members working to meet the needs of industry 5 to 10 years into the future. For years, the industry has been using bearing models based on archaic performance data. The new test rig supports bearing evaluations under today's simulated engine loads of up to 250 bar peak cylinder pressure. We measure bearing friction, minimum oil film thickness and lubricant flow rates, which are critical to understanding bearing friction and updating bearing simulation models.

Our dual-fuel technologies enable large, high-horsepower engines in the rail and mining industries to use a combination of diesel fuel and natural gas to reduce operating costs and harmful

We developed high-fidelity, high-precision systems to assess how the energy flow of subsystems in a plug-in hybrid electric vehicle affects the optimization of electrified powertrains.

D023424

FAR LEFT: A mobile version of our Direct Electronic Vehicle Control system evaluates the fuel economy of Class 8 vehicles on a test track. The system controls acceleration and braking for fuel consumption testing to the SAE J1321 standard.

NEAR LEFT: We developed a dynamic bearing test rig to measure bearing friction, oil film thickness and lubricant flow rates under simulated engine loads up to 250 bar peak cylinder pressure.

emissions. We completed a six-year contract with a large engine manufacturer to develop and put into production a dual-fuel conversion kit for locomotives, allowing engines to operate on up to 80 percent liquefied natural gas. These engines meet EPA Tier 3 locomotive emissions requirements while retaining the ability to run on 100 percent diesel fuel. A similar approach also dramatically increases the use of natural gas in mining trucks. The method replaces stock diesel injectors with optimized common rail injectors, offering the industry a lower-cost alternative to more complex technologies under consideration. Initial results show a possible path to meeting EPA Tier 4 non-road emissions requirements without aftertreatment or exhaust gas recirculation systems.

This year, SwRI engineers developed a mobile version of our Direct Electronic Vehicle Control (DEVCon™) system to evaluate the fuel economy of Class 8 vehicles on a test track. DEVCon-mobile is a first-of-its-kind system to control acceleration and braking for fuel consumption testing to the SAE J1321 standard. The system initially records a human driver's pedal positions and then allows a robot to make small corrections to improve test repeatability. This increased driving precision allows SwRI clients to identify products that offer as little as 1 percent fuel consumption improvement.

In 2018, we modified the ASTM Volvo T-13 test that lubricant manufacturers use to develop products to extend the life of oils used in heavy-duty trucking applications. To mitigate fuel and hardware costs for the 360-hour procedure, our updated test method helps quantify how metal contamination, turbocharger selection, operating temperature and fuel properties contribute to the degradation of oil.

For more than 60 years, SwRI has operated the U.S. Army Tank Automotive Research, Development and Engineering Center (TARDEC) Fuels and Lubricants Research Facility. Located at SwRI, TARDEC is a government-owned, contractor-operated facility providing advanced research, development and engineering, including filtration research, for the U.S. Army and other government agencies. Based on 2017's diesel fuel filter test advances, SwRI is developing new methods for evaluating fuel, hydraulic fluid and lubricating oil filters under real-world conditions. These filters typically experience vibration, temperature cycling and variable flow rates in actual service. We are adapting current laboratory test technology to integrate vibration and cyclic flow effects to evaluate filter performance under dynamic conditions. These new tests supplement our existing standardized filter test capabilities.

SwRI is a leader in developing and managing consortia that allow clients to pool their resources for pre-competitive research. Seven automotive consortia are currently active, including CHEDE mentioned previously. Also among these is the High-Efficiency Dilute Gasoline Engine consortium, which has spent more than a decade pursuing lower emissions and higher gas mileage. The Advanced Engine Fluids consortium is addressing low-speed pre-ignition problems, while the Advanced Combustion Catalyst and Aftertreatment Technology consortium began its second phase in 2018. The Energy Storage System Evaluation & Safety consortium is also in its second phase, evaluating and characterizing member-selected sets of batteries for performance, safety, cycle life and manufacturing. The consortium also benchmarks the latest electric vehicles.

For more information visit **automotive-engineering.swri.org** or contact Vice President Daniel W. Stewart, P.E., at 210.522.3657 or daniel.stewart@swri.org, or Vice President Steven D. Marty, P.E., at 210.522.5929 or steven.marty@swri.org.

An SwRI-developed combustion system enhances in-cylinder air motion at low speeds for large-bore spark-ignited engines. The design allows gasoline and other spark-ignited engines to be competitive in medium- and heavy-duty applications.

MULTIPHASE DEVLOPMENT

INITIAL LICENSE OF **40** YEARS

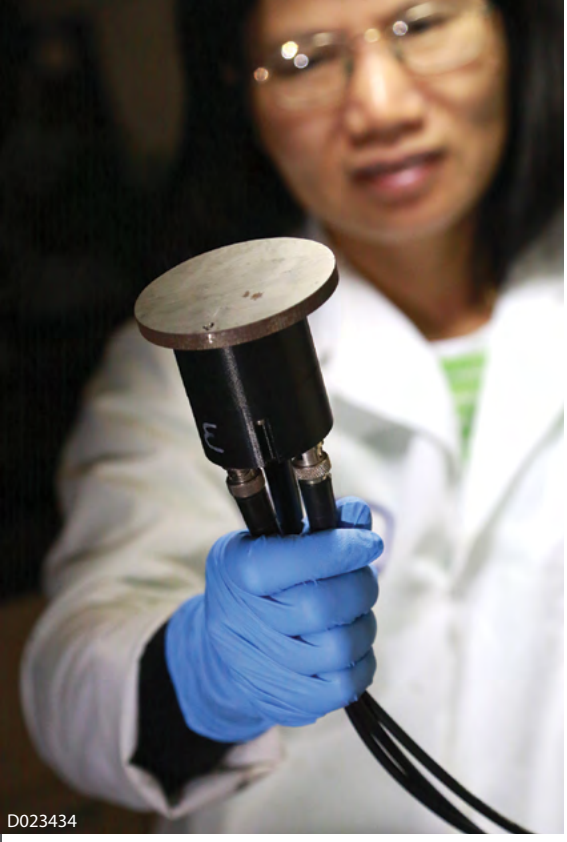
STORING **9,500** TONS OF WASTE

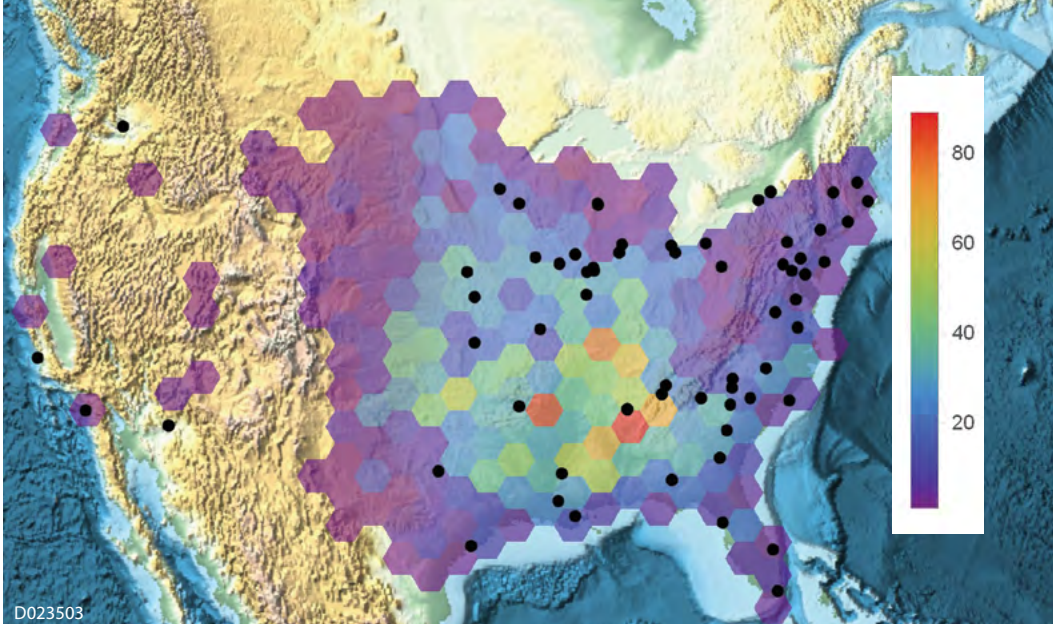
IN UP TO **10,000** CANISTERS

SwRI is helping NRC develop an environmental impact statement for a proposed spent nuclear fuel and high-level radioactive waste storage facility in southeastern New Mexico.

CENTER FOR NUCLEAR WASTE REGULATORY ANALYSES

- Geological & Geophysical Investigations
- Groundwater Resource Evaluations
- Chemical & Radiological Contaminant Transport
- Laboratory, Field & Numerical Analyses
- Corrosion Detection & Mitigation
- Materials Life Prediction
- Risk & Performance Assessments
- Environmental Impact Assessments
- Geoscience Processes
- Climate Change Impact Assessments
- Structural Integrity Analyses
- Reliability & Operational Safety Analyses
- Regulatory Analysis & Guidance
- Fire Protection & Forensic Analyses
- Material Aging & Degradation
- Natural & Human-Induced Hazard Assessments
- Structure, System & Component Fragility Analyses
- Pipeline Failure Analyses
- Probabilistic Risk Assessments





ABOVE: SwRI studied the risk of tornado damage to U.S. nuclear power plants (plant locations indicated by black dots on the map). The map shows the number of higher-intensity tornados inside the hexagonal regions over the last 20 years.

LEFT: To combat corrosion in above-ground storage tanks used by the petroleum and nuclear industries, SwRI developed this prototype monitoring sensor to quickly evaluate the effectiveness of various corrosion control measures.

In 2018, Southwest Research Institute received a five-year renewal from the Nuclear Regulatory Commission to operate the Center for Nuclear Waste Regulatory Analyses. SwRI has hosted CNWRA®, a federally funded research and development center, for more than 30 years to support NRC's regulatory responsibilities related to radioactive waste storage, transportation and disposal. Research and technical assistance conducted by CNWRA both draws from and further develops its broad expertise in earth science and engineering with extensive applications.

Over the past seven years, we have helped NRC review license amendment requests from nuclear power plants transitioning from prescriptive to risk-informed, performance-based fire protection programs. More recently, our staff has supported NRC's complete overhaul of the Fire Protection Significance Determination Process to incorporate experience and new fire modeling data.

We also completed risk analyses of the effects of loss-of-coolant accidents and debris contamination on emergency core cooling systems in pressurized-water nuclear power plants. In addition, we completed a general evaluation of associated risks in boiling-water reactors across the United States. SwRI developed a new computational model that quantifies the pressure rise caused by a high-energy arcing fault in enclosures such as electrical cabinets used in nuclear power plants. In past years, we have used computational fluid dynamics to quantify the thermal impact from such electrical faults on nearby combustibles and equipment.

In the last year, SwRI helped NRC finalize an environmental assessment of a uranium recovery project in Campbell County, Wyoming. Institute subject-matter experts analyzed possible effects on groundwater, ecology, air quality, geology, soils, public and occupational health, and cumulative impacts, among others.

The Institute also helped NRC evaluate the U.S. Army's proposed oversight and maintenance activities at Jefferson Proving Ground, a legacy military testing site near Madison, Indiana. Established in 1940 to test all types of ammunition and bombs, the site contains unexploded ordnance, increasing risks and complications to site remediation.

In 2018, progress on the Next Generation Liquefaction (NGL) project culminated in a second workshop showcasing a new NGL database. Liquefaction occurs when earthquakes shake sandy, water-saturated layers that lie beneath seemingly solid terrain, causing the ground to liquefy. Developed by SwRI and UCLA with NRC funding, the database catalogs characteristics and test results from locations where seismically induced soil liquefaction has, or may have, occurred.

SwRI and NRC staff members updated the Senior Seismic Hazard Analysis Committee's guidelines, which outline a formal process eliciting expert judgments to help characterize the seismic hazards for sites around the world. The guidance incorporates lessons learned from global applications and the re-assessments of seismic hazards at nuclear power plants across the U.S. after the 2011 Fukushima Daiichi incident in Japan.

For the alternative energy industry, SwRI investigated using dual-reservoir, pumped-storage hydropower to store renewable energy generated in West Texas. During peak production when energy is plentiful, water is pumped from a lower reservoir to an upper reservoir. During peak demand or low production, the water is released through turbines to produce electric power. Large, grid-scale energy storage units could bridge the gap between late-afternoon peaks in energy demand and the drop in solar energy production as the sun sets.

For more information visit **cnwra.swri.org** or contact Executive Director Dr. Wesley Patrick at 210.522.5158 or wesley.patrick@swri.org.

Fire specialists expose fully charged electric vehicle batteries to gasoline pool fires. Part of a larger program evaluating battery performance, the test assesses their resistance to fire and explosion.

D023492

CHEMISTRY & CHEMICAL ENGINEERING

- Drug Discovery
- Medicinal Chemistry
- Process Development
- Microencapsulation
- Biomaterials Engineering
- Materials Chemistry
- Pilot Plant Development
- Refinery Operations & Optimization
- Technoeconomic Feasibility Studies
- Biofuels Development
- Homeland Security
- Fire Testing & Research
- Analytical Chemistry
- Environmental Monitoring
- Chemical Forensics
- Radiation Services
- Risk & Hazard Analysis
- Fire Protection Engineering
- Chemical & Biological Warfare Defense
- Medical Countermeasures

Southwest Research Institute chemists and chemical engineers help clients address homeland security threats, develop new fuel and chemical production techniques, and devise solutions to emerging challenges to human health and safety. We specialize in creating novel, scalable processes to produce advanced drug formulations, enhanced consumer products, and specialty chemicals and fuels.

In 2018, SwRI chemical engineers continued designing, fabricating and validating novel processes to upgrade and refine hydrocarbon products from natural gas, bio-based feedstocks and other sources. To improve safety, increase efficiency and decrease waste, we design, build and test novel processes to generate fuels, polymers and specialty chemicals. Using our extensive lab facilities and pilot plant expertise, we developed an innovative, continuous process to produce a thin aerogel film with a high gas content and low dielectric constant. These polymer insulating materials, used in thermal and electronic applications, are currently produced using less efficient batch techniques.

We are leveraging 70 years of experience in microencapsulation to create innovative products for the pharmaceutical, veterinary, food, nutraceutical, agricultural and consumer markets. We continue to enhance our integrated Current Good Manufacturing Practices facilities to expand pharmaceutical production for clinical trials and commercial sales. During the past year, SwRI manufactured a CGMP supply of eRapa™, a proprietary formulation of rapamycin designed to treat prostate cancer, for a Phase 1 clinical trial.

Applications for drug delivery implant technology are growing, particularly to ensure treatment compliance. Our scientists are designing a drug-eluting platform for malaria prevention as well as Parkinson's disease, opioid addiction and addiction relapse treatments.

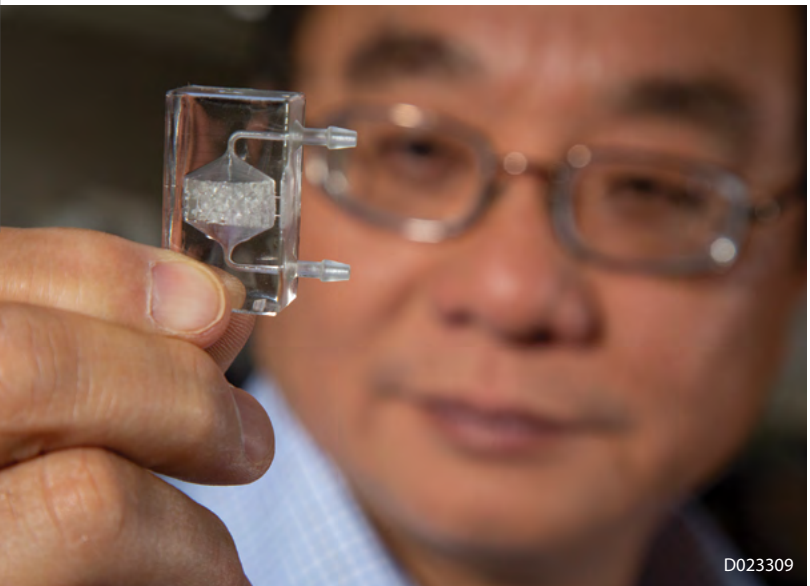
In the drug synthesis arena, SwRI is developing techniques to lower the treatment costs for malaria, one of humanity's most deadly infectious diseases. Funded by a Bill & Melinda Gates Foundation grant, the novel process is using a new chemical process to cost-effectively synthesize high-quality, semisynthetic artemisinin, the primary drug used to treat the mosquito-borne illness. While highly effective, conventional artemisinin treatments are costly, which can be a barrier to widespread treatment for affected communities.

To provide an immediate response to industrial and combat exposures, we are developing a medical device to deliver a precise dose of an intranasal cyanide antidote. Chemists are collaborating with engineers across the Institute to ensure the device consistently delivers an exact volume of the spray.

SwRI also continued more than 30 years of supporting chemical weapons destruction. For the Defense Advanced Research Projects Agency, we are developing a tactical vehicle capable of driving in, destroying chemical warfare agents with its own diesel engine and then driving out. Chemists also developed a lightweight ammonia-based technique to scrub acid gas from the engine exhaust. SwRI will build and test this half-ton pickup-truck-based system in 2019.

We also continue to operate one of the world's largest organizations dedicated to fire technology, research and testing. Our multidisciplinary fire and explosion testing and research services include third-party evaluations to ensure materials and products meet standards. New building codes will allow for environmentally friendly, seismically strong all-wood midrise structures up to 15 stories high. SwRI has developed new tests to examine the fire performance of wooden joint assemblies and to measure the thermal resistance of glues used in laminated timbers.

For more information visit **chemistry.swri.org** or contact Vice President Dr. Michael MacNaughton at 210.522.5162 or michael.macnaughton@swri.org.



ABOVE: Our chemical engineers have developed a pilot plant to continuously produce polymer insulation materials. These aerogel films have high gas content, creating an ultra-light material with low thermal conductivity.

LEFT: SwRI invented this novel cell expansion bioreactor with internal funding. Fabricated by 3D printing, the automated, single-use, scalable device will propagate stem cells for tomorrow's personalized medical treatments.

DEFENSE & INTELLIGENCE SOLUTIONS

- Information Assurance
- Analysis, Analytics, Visualization & Reporting
- Avionics-Based Open Systems
- Signal Analysis & Processing
- Deep Learning
- Electronic Warfare
- Intelligence & Tactical Networking
- GPS Engineering
- Geolocation
- Signals Intelligence
- Intelligence, Surveillance & Reconnaissance
- Multi-INT Processing, Exploitation & Dissemination
- RADAR Simulation
- Weapon System Integration & Sustainment
- Aircraft Data Recorders
- Autonomous Sensors/Sensing
- Communications Solutions
- Information Exploitation
- Aircraft Simulation
- Array Processing

This AF-100 antenna efficiently transmits and receives signals reflected back to Earth without tuning. Its two dipole elements, mounted at right angles to each other, allow scientists to characterize the returned signal.

One of the longest-standing programs at Southwest Research Institute is our research in radio frequency surveillance and communications intelligence. Working with software and automated systems engineers, signals intelligence specialists help the U.S. and allied militaries meet the latest information processing demands while addressing cyber warfare threats.

In 2018, SwRI added new radar and geolocation capabilities. Meanwhile, in an environment of increased wireless complexity and interoperability, we anticipate increased demand for autonomy, standardized architectures and hardware/software services for our clients.

Building on decades of work with shipboard and ground-based systems, engineers completed internally funded research programs in space and near-space sensors that resulted in two externally funded projects. Engineers ported SwRI's signals intelligence software to ruggedized hardware meeting new OpenVPX defense department interoperability standards. We evaluated the resulting digitized radio frequency recording system on board a stratospheric balloon. SwRI developed the Time Varying Spatial Correlation algorithm and assessed how accurately it locates priority RF signals from a space platform.

Other programs led to launching a second ionospheric sounding facility on our San Antonio grounds. The facility provides precision ground-based measurement of ionospheric conditions, an improvement over launching instruments into near space via sounding rockets. With a smaller footprint than rocket launch sites, the facility also allows longer-duration studies than the minutes of data collected before rockets fall back to Earth.

In related research, engineers are using our AF-100 antenna for a novel, SwRI-developed VIS-3000 sounder system. Sounders, or ionosondes, use radar techniques to measure the virtual height of the ionosphere, which reflects high-frequency radio communication signals back to Earth for beyond-line-of-sight communications. Typical sounders require 200 to 300 watts to make these measurements, but the VIS-3000 sounder uses as little as one milliwatt to do the job.

In 2018, SwRI also explored a new area of signal intelligence research known as "geofencing," which collects and analyzes radio frequency energy from a defined area to identify the signal source and location precisely.

Our office in Warner Robins, Georgia, serves the aerospace and defense communities with a wide array of capabilities and expertise in avionics, electronic warfare, instrumentation, software and systems engineering and continues expanding these capabilities to new platforms.


D023235

In 2018, SwRI delivered advanced communications intelligence (COMINT) technology to U.S. Navy and allied clients. The system includes an array of above- and below-decks hardware and software to meet growing COMINT demands.

Aerospace electronics and software engineers from across the Institute are collaborating to develop a new sensor integration unit for the U.S. Air Force fleet of F-16 Fighting Falcon aircraft. The unit collects and correlates data from a number of sensors to provide Air Force pilots with improved situational awareness via a single integrated display.

This year, we received certification to AS9100:2016, a quality management system for the aerospace industry developed by SAE International in collaboration with the European Association of Aerospace Industries. To meet the challenges of the changing global business landscape, we are adopting the latest Capability Maturity Model Integration Institute quality system, CMMI® Development 2.0.

For more information visit **defense.swri.org** or contact Vice President Nils Smith, P.E., at 210.522.3685 or nils.smith@swri.org.


D023500

SwRI engineers used OpenVPX processing hardware to support a digitized radio frequency recording system evaluated on a stratospheric balloon. OpenVPX is a set of defense industry interoperability specifications.

13,000

MILES OF MANAGED ROADWAYS

9 OF THE 25

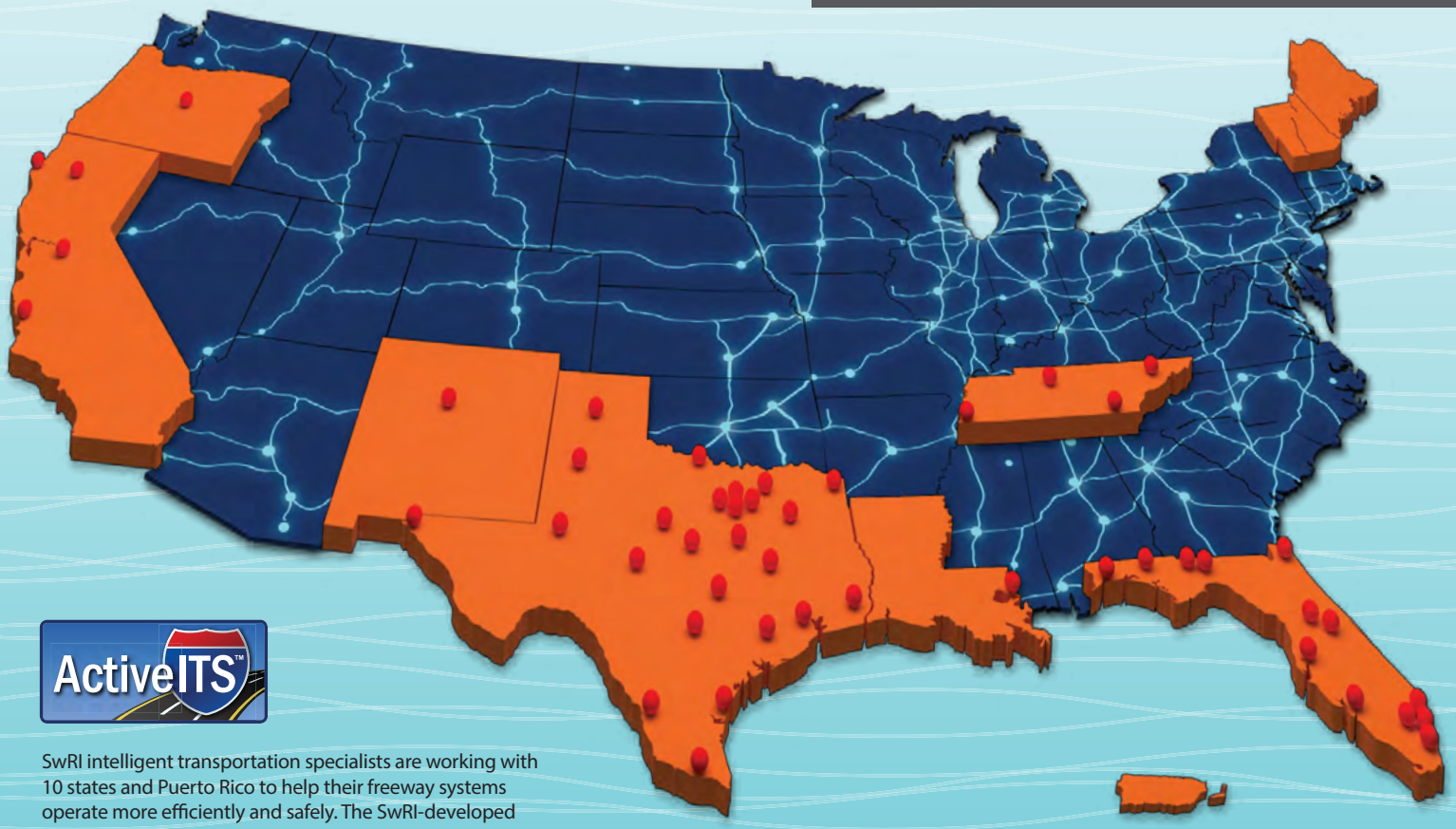
LARGEST U.S. CITIES

50+

DEPLOYMENTS

INTELLIGENT SYSTEMS

- Unmanned Systems
- Decision Technologies
- Robotics
- Active Safety Systems
- Intelligent Transportation Systems
- Process Improvement
- Situational Awareness
- Human Performance
- Machine Vision
- ROS-Industrial
- Connected Vehicles
- Perception Systems
- Localization Technologies
- High-Reliability Systems
- Flight Test Technologies
- Advanced Manufacturing Technologies
- Automated Driving
- Intelligent Inspection Technologies
- Big Data & Analytics
- Cybersecurity
- Penetration Testing
- Leak Detection Systems
- Advanced Transportation Management Systems
- Advanced Inspection Systems



ActiveITS™

SwRI intelligent transportation specialists are working with 10 states and Puerto Rico to help their freeway systems operate more efficiently and safely. The SwRI-developed ActiveITS™ system provides the core of these advanced traffic management systems.

D023490

The "Wingman" system pairs a robotic vehicle (left) with a soldier-operated vehicle. Equipped with unmanned mobility, automated target tracking and a remotely operated weapon system, the robotic Wingman vehicle allows soldiers to engage targets from covered positions.

IMAGE COURTESY U.S. ARMY

This flexible robot system uses ROS-I and advanced sensors to conduct real-time path planning and analysis as it moves about an aircraft. An onboard computer processes sensor data to create on-the-fly robot motion paths without manual programming.

As Southwest Research Institute's intelligent transportation systems expand across the country, our novel software, robot, automated driving and smart technologies are also solving real-world problems around the globe.

SwRI is now providing advanced transportation management system (ATMS) technology and services to 10 states and Puerto Rico. In the U.S., building highways in urban areas can cost as much as $2 million per lane, per mile, making it financially impossible to build our way out of traffic congestion. ATMS technology quickly identifies accidents and musters appropriate emergency and clearance responses to return traffic to free-flow conditions as quickly as possible.

In a related area, SwRI is also a leader in connected vehicle (CV) and automated driving technologies. Last year, SwRI introduced new data and software tools designed to identify wrong-way drivers and to make wireless communications between vehicles and infrastructure safer. A comprehensive CV test suite verifies compliance with industry standards for vehicle-to-vehicle safety communications, evaluating interoperability and data integrity when devices communicate over wireless networks. SwRI is also advancing the state-of-the-art in cybersecurity for today's vehicles and transportation management infrastructure and tomorrow's automated and connected vehicle technologies.

While CV technology is a cornerstone for tomorrow's automated vehicles, sensor and localization technologies are also critical to help navigate and maintain roadway position. SwRI blends these technologies for diverse applications, from passenger vehicles to low-speed automated shuttles and tractor trailers at shipping depots. For the military, automated vehicles help protect the warfighter from hazardous situations.

SwRI's award-winning Smart LEak Detection System (SLED) uses computer vision and machine learning to detect pipeline leaks. SwRI is using drones to expand SLED's capabilities to detect gaseous methane leaks as well as liquid hydrocarbon spills at sea.

D023440

In other automation applications, SwRI uses the ROS-Industrial open-source project to extend the advanced capabilities of the Robot Operating System (ROS) to advanced manufacturing. In 2018, SwRI was part of a team that demonstrated using ROS-I to bridge robot programming with the MTConnect open standard. By enabling communications between a robot and a machine tool, the ROS-I/MTConnect solution demonstrates how open-source software supports smart manufacturing applications. SwRI curates the ROS-I open source framework and is one of the leaders of the ROS-I consortium.

Other robotics activities include developing a collaborative robotics laboratory to develop "cobot" technology. While conventional robots are walled off from humans for safety reasons, collaborative robots work alongside human operators, performing manual tasks. SwRI develops unique human-robot interfaces, perception technologies and advanced path planning capabilities that allow cobots to work safely and efficiently with humans.

We're also helping the U.S. Department of Defense improve system interoperability in aircraft and ground vehicles. Overseas, an SwRI-led team is developing unmanned aerial systems to fly into the containment vessels of the damaged units at Japan's Fukushima Daiichi nuclear power station and assess conditions. Working with the client and academic collaborators, SwRI engineers are helping adapt small drones to autonomously operate within this challenging environment.

Closer to home, SwRI continues to support local small- and medium-sized manufacturers, operating a branch of the Texas Manufacturing Assistance Center (TMAC). In 2018, TMAC provided strategic consulting and process improvement training, and introduced collaborative robotics to South Central Texas small businesses.

For more information visit **intelligentsystems.swri.org** or contact Vice President Dr. Steve Dellenback at 210.522.3914 or steve.dellenback@swri.org.

MAX PRESSURE	MAX DIFFERENTIAL PRESSURE	OPERATING TEMPERATURE RANGE	OPERATING FLUIDS	SIMULATED WELL DEPTH
10,000 PSI	2,000 PSID	150 – 275°F	NITROGEN & METHANE	25,000 FT

This one-of-a-kind test facility mimics dynamic gas flow conditions in deepwater offshore oil production applications, providing critical performance data for gas-lift technology used for enhanced oil recovery.

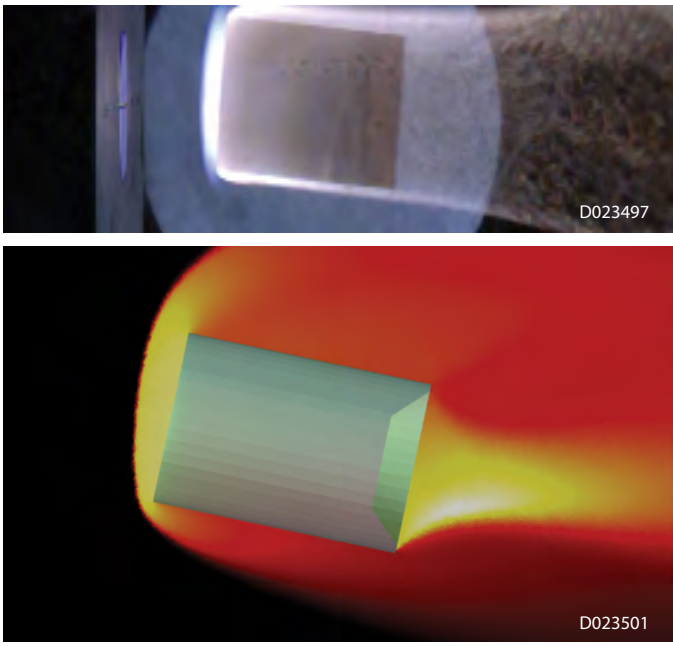
D023487

MECHANICAL ENGINEERING

- Computational Fluid Dynamics
- Deep Ocean Simulations
- Fracture Mechanics
- Flow Measurement
- Multiphase Flow
- Probabilistic Failure Analysis
- Environmental Testing
- Surface Engineering & Coatings
- Telecommunications Evaluations
- Structural Mechanics
- Failure Analysis
- Eddy Current Modeling
- Diagnostic Software
- Thermal & Corrosion Analysis
- Nondestructive Evaluation
- Pipeline Compression
- Acoustics
- Biomechanics & Biomaterials
- Magnetostrictive Sensors
- Materials Integrity & Life Prediction
- Terminal Ballistics
- Guided Wave Inspection
- Aerodynamics
- Propellant Dynamics
- Supercritical CO_2 Power Cycles

D023495

SwRI supported hydrostatic testing of a new deep ocean submarine. We instrumented the hull, developed an automatic data acquisition system and evaluated the vehicle's pressure equipment.



TOP: For hypersonic weapons research, SwRI launched a 5-centimeter blunt object at 16 times the speed of sound. Note the resulting luminous gas in front of the flight body and the ablated material in its wake. BOTTOM: The corresponding computational image estimates the temperatures.

Southwest Research Institute provides a range of research, development and evaluation services to both government and industry clients. We offer extensive expertise and novel facilities supporting the needs of the defense and energy departments as well as the civil aerospace and oil and gas industries, among others.

As a leader in providing solutions to minimize leaks from pressurized infrastructure such as pipelines, refineries and chemical processing plants, we successfully field-tested various new pipeline leak detection systems this year. For offshore oil spills, dispersal chemicals are typically used to break the spilled product into small droplets. We worked with the U.S. Department of the Interior to develop techniques that optimize dispersant selection and delivery.

Hydrogen embrittlement can silently, without warning, compromise the offshore pipeline systems that transport about a third of the world's oil supply. The presence of hydrogen sulfide in oil can result in hydrogen embrittlement, leading to environmentally assisted cracking that can reduce the operational life of pipelines by decades. We are leading an effort to relate hydrogen permeation and trapping with the degradation of a material's resistance to cracking.

SwRI is taking three decades of experience keeping aging military aircraft fleets operational and extending this structural integrity expertise to new applications. When infrastructure exceeds its original design life, we perform fitness-for-service (FFS) evaluations using a variety of tools and technologies. For example, we used NASGRO® fracture mechanics and fatigue crack growth analyses to complete FFS evaluations for a large U.S. government wind tunnel constructed more than 50 years ago. SwRI also uses classical fatigue analysis to support the mechanical and structural design of aerospace and related systems.

In the defense arena, SwRI is investigating hypersonic weapons that could maneuver at speeds between Mach 5 and 20 at high altitudes, providing offensive targeting flexibility and challenges to missile defense. We used our new two-stage light gas gun to launch blunt bodies at Mach 16 at simulated high-altitude conditions and recorded flight characteristics of the body with high-speed digital cameras. Corresponding computations confirmed shock wave location and conditions, allowing engineers to estimate that the gas in front of the projectile exceeded 6,000 degrees Kelvin. These temperatures are hotter than the surface of the Sun, so thermal protection systems made of materials such as carbon-carbon composites and, potentially, ceramics are required for extended exposures.

We have a long history of supporting U.S. launch vehicle development, providing propellant management and flight stability solutions. Over the past decade, we've expanded this research to include commercial launch providers, addressing instability associated with turbomachinery, combustion, pressurization and longitudinal aerodynamics. We are part of a team designing, building and testing fuel system accumulators for the Antares rocket, which has flown seven times as part of NASA's Commercial Resupply Services program.

Visit **mechanicalengineering.swri.org** for more information or contact Vice President Danny Deffenbaugh at 210.522.2384 or danny.deffenbaugh@swri.org.

IMAGE COURTESY FIVE DEEPS EXPEDITION

SUPPLIES
10
KILOVOLTS

IN
23.4
MICROSECONDS

OPERATING VOLTAGE
10.5
KILOVOLTS

WEIGHT OF
1/2 INCH DEVICE
<4
GRAMS

RADIATION TOLERANCE
>100K
RADS

SPACE SCIENCE & ENGINEERING

- Planetary Science
- Magnetospheric Physics
- Solar & Heliospheric Physics
- Geological Structural Analyses
- Spaceflight Science Instruments
- Spacecraft Avionics
- Electromechanical Systems
- Water Resource Management
- Power Systems
- Small Satellite Development
- Spacecraft Management
- Data Analysis & Science Support
- Science & Mission Operations
- Lighter-Than-Air Systems
- Energy Exploration & Production

SwRI's Optocoupler power conversion technology has been selected for three instruments bound for Jupiter's moon Europa. The high-reliability device, developed with internal funding, overcomes problems similar systems have had operating in space.

D023322

For Project ESPRESSO, SwRI flew a specialized, small-scale vacuum chamber at zero gravity to test technology for exploring low-gravity, airless worlds. We demonstrated miniature grapples for nano-scale landers designed to collect samples from bodies such as the Moon and asteroids.

D023493

Southwest Research Institute offers one of the nation's leading space science and engineering programs, conducting fundamental research and developing innovative technology. Our staff investigates space phenomena, develops payload instruments and electronics, and leads entire space missions. Earth science expertise complements our space research.

SwRI is home to principal investigators of four pioneering NASA missions. These include two planetary programs in progress — the Juno mission to Jupiter, now halfway through its primary mission — and New Horizons, which followed up its dramatic Pluto encounter with a flyby of Kuiper Belt object 2014 MU69 on January 1, 2019. A third planetary mission will encounter multiple Trojan asteroids for the first time. The Lucy spacecraft is scheduled to launch in 2021 to study some of the most ancient objects in the solar system. The Magnetospheric Multiscale mission was extended in 2018 to continue the steady stream of discoveries about magnetic reconnection, explosive phenomena seen throughout the universe, studied on an electron scale in the near-Earth environment.

Also operating in Earth orbit, the SwRI-built Cyclone Global Navigation Satellite System (CYGNSS) collected critical wind speed data during 2018's particularly active North Atlantic hurricane season. Scientists verified CYGNSS measurements with 25 coordinated hurricane hunter aircraft flyovers. CYGNSS can monitor a storm every few hours, providing data that can be used to improve intensification modeling, which could ultimately save lives.

In the space engineering arena, progress continues on SCORPIO, an eight-channel imager and spectrograph designed to complement the 8-meter Gemini South telescope in Chile. SCORPIO will allow scientists to observe the whole universe — from exploding stars to black holes and exoplanets — with unparalleled sensitivity.

The latest versions of SwRI's Ultraviolet Spectrograph (UVS) are slated to fly on two upcoming missions to the Jupiter system. The UVS instruments will study the surface and thin exospheres of Jupiter's icy moons. After final calibrations, JUICE-UVS will ship to France next summer for integration into the European Space Agency's JUpiter ICy moons Explorer spacecraft, scheduled to launch in 2022. Europa-UVS, slated to fly on NASA's Europa mission, begins fabrication in 2019. The Europa Clipper, scheduled to launch in 2023, will also host SwRI's ultra-sensitive MAss Spectrometer for Planetary EXploration (MASPEX).

Space scientists are developing PUNCH, a proposed Polarimeter to UNify the Corona and Heliosphere mission to observe the "no-man's land" between the outer solar corona and the solar wind. SwRI prototyped a wide-field imager for the mission and will host a NASA site visit in early 2019 for the mission evaluation phase of the project.

Our solar system formation specialists advance evolution models using the latest scientific data, while astronomers look beyond, studying other stars and their planetary systems and what they tell us about our place in the universe.

SwRI's earth science group supports petroleum and water resource management. Workshops, field seminars and joint industry projects led by SwRI staff members include courses and consortia focused on the Permian Basin, Eagle Ford and Austin Chalk areas of South Texas. Water quality and availability remain important global and local concerns. SwRI is studying how surface water is linked with groundwater and assessing how factors such as urbanization and climate change will affect future water resources.

For more information visit **spacescience.swri.org** or contact Vice President Dr. James L. Burch at 210.522.2526 or jim.burch@swri.org.

D023443

SwRI prototyped this Wide Field Imager for the proposed PUNCH mission. The dark baffles in the top recess allow the instrument to image objects a thousand times fainter than the Milky Way.

CONSOLIDATED STATEMENT OF ACTIVITIES in thousands of dollars

	For the year ended September 28, 2018
Commercial revenue	$235,422
Government revenue	344,271
Contract underruns, net	3,996
Total revenue	583,689
Direct project costs	333,076
Operating income	250,613
Division operating expenses	132,562
Depreciation – research equipment	10,920
General overhead	54,289
Depreciation – general facilities	17,087
Internal research	6,789
Income from operations before federal income tax expense	28,966
Federal income tax expense	2,044
Income from operations	26,922
Investment income	7,882
Postemployment benefits liability actuarial adjustments	3,604
Change in unrestricted net assets	38,408
Net assets at beginning of year	519,575
Net assets at end of year	$557,983

NET ASSETS | in millions of dollars

BOARD OF DIRECTORS

OFFICERS

VICE PRESIDENTS

ADVISORY TRUSTEES

Mr. James D. Goudge
Chairman
Broadway Bank
San Antonio, Texas

Mr. William "Bill" E. Greehey
Chairman of the Board
NuStar Energy LP
San Antonio, Texas

Mr. Phillip D. Green
Chairman and CEO
Cullen/Frost Bank
San Antonio, Texas

Dr. Kennon H. Guglielmo
Chief Technology Officer
EControls
San Antonio, Texas

Ms. Tracy Hayes
President
CWS Corporate Housing
Austin, Texas

Dr. Peter H. Hennings
Principal Investigator, Center for Integrated Seismicity Research
Bureau of Economic Geology
The University of Texas at Austin
Austin, Texas

Dr. William L. Henrich, MACP
President
UT Health San Antonio
San Antonio, Texas

Mr. Benny H. Hughes
Of Counsel
Orgain, Bell & Tucker LLP
Beaumont, Texas

Dr. Anthony J. Infante
Professor of Pediatrics
UT Health San Antonio
San Antonio, Texas

Mr. Mark M. Johnson
Managing Director of Regional and Specialty Banking
Texas Capital Bank
San Antonio, Texas

Dr. Dale E. Klein
Associate Vice Chancellor for Research
The University of Texas System
Austin, Texas

Mr. William "Bill" R. Klesse
CEO and Chairman of the Board (Retired)
Valero Energy Corporation
San Antonio, Texas

Mr. Jeffrey "Jeff" Kodosky
Co-Founder and Fellow
National Instruments
Austin, Texas

Mr. Joseph "Joe" R. Krier
San Antonio, Texas

Ms. Carolyn Labatt
CEO
Computer Solutions Ltd.
San Antonio, Texas

Lt. Gen. Frank F. Ledford Jr., USA (Ret.)
Former Surgeon General of the Army
President (Retired)
Texas Biomedical Research Institute
San Antonio, Texas

Mr. Gordon Logan
Founder and CEO
Sports Clips
Georgetown, Texas

Dr. Adena Williams Loston
President
St. Philip's College
San Antonio, Texas

Ms. Kimberly S. Lubel
San Antonio, Texas

Mr. Chris May
Principal
Deloitte Financial Advisory Services
Austin, Texas

Mr. Mark P. Mays
Mays Family Enterprises Inc.
San Antonio, Texas

Gen. William V. McBride, USAF (Ret.)
San Antonio, Texas

Mr. Robert S. McClane
President
McClane Partners LLC
San Antonio, Texas

Lt. Gen. James McLaughlin, USAF (ret.)
McLaughlin Global Associates LLC
New Braunfels, Texas

Ms. Katrina McMurrian
Executive Director
Critical Consumer Issues Forum/ Nuclear Waste Strategy Coalition
Franklin, Tennessee

Mr. Thomas M. Mengler, J.D.
President
St. Mary's University
San Antonio, Texas

Mr. John "Jack" K. Meyer
Senior Partner
South Texas Syndicate
San Antonio, Texas

Dr. Jon N. Moline
President Emeritus
Texas Lutheran University
Seguin, Texas

Mr. Brad Morrison
Founder and CEO
Innové LLC
Boerne, Texas

Dr. Sharon Mosher
Dean, Jackson School of Geosciences
The University of Texas at Austin
Austin, Texas

Mr. Robert "Bob" G. Newman
Partner (Retired)
Fulbright & Jaworski LLP
San Antonio, Texas

Ms. Jan Newton
President (Retired)
AT&T Texas
Boerne, Texas

Dr. Gabriele Niederauer
President and CEO
Bluegrass Vascular Technologies
San Antonio, Texas

Mr. Richard Perez
President and CEO
San Antonio Chamber of Commerce
San Antonio, Texas

Dr. Richard "Rusty" E. Phillips
Vice President, Technology
BioStable Science & Engineering Inc.
Austin, Texas

Dr. Carl F. Raba Jr., P.E.
San Antonio, Texas

ADVISORY TRUSTEES

HIGHLIGHTS

441 staff members received service awards recognizing 7,580 cumulative years of service

441 / 7,580

20

20 local teachers trained to use NASA telescope

11-12-18

Technology Today: The Podcast launched

234

234 people participated in SwRI Cares events benefitting United Way agencies

Record-setting $810,268 raised for United Way

>$800K

9 / 812

9 blood drives, 812 donations

750

750 hours supporting SA Food Bank

>3,800

More than 3,800 meals delivered to senior neighbors

All inquiries should be addressed to:
Communications Department
Southwest Research Institute
P.O. Drawer 28510
San Antonio, Texas
78228-0510
Phone 210.522.2257
Fax 210.522.3547
or solutions@swri.org

Southwest Research Institute
6220 Culebra Road
P.O. Drawer 28510
San Antonio, Texas 78228-0510
United States

Nonprofit Org.
U.S. POSTAGE
PAID
Permit No. 234
San Antonio, Texas

210.522.2122
Fax 210.522.3496

solutions@swri.org

swri.org

Like. Share. Follow. Listen.

Deep Sea to Deep Space®