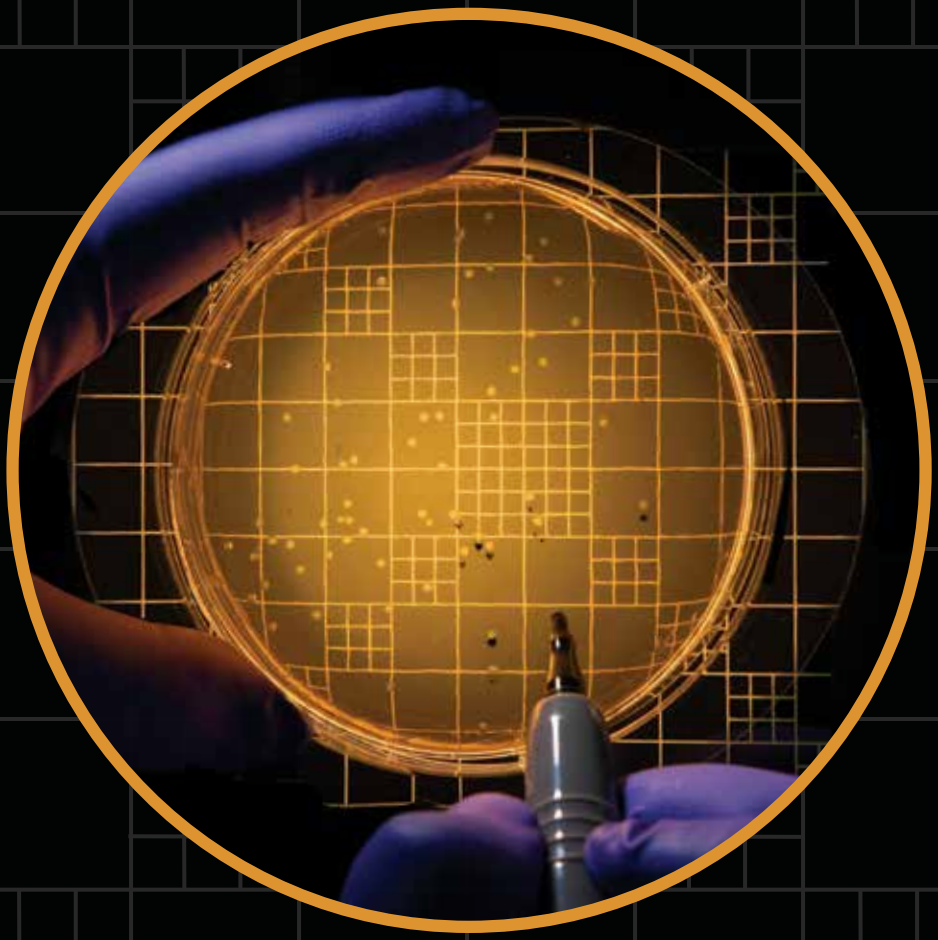


ANNUAL REPORT 2020

SOUTHWEST RESEARCH INSTITUTE®

SwRI COMBATS COVID-19

When 2020 began, no one could anticipate what the year would bring.

Soon after news broke of the outbreak of a novel coronavirus, Southwest Research Institute began working with the scientific and medical communities in San Antonio and across the U.S. to gain scientific insights into the disease. Once a 3D image of the virus protein was made available, SwRI's drug development team used our Rhodium™ software to virtually screen millions of drug compounds to find potential treatments. In just 21 days, our chemists had screened 5 million possible compounds, selected 60 for toxicity testing, and ultimately recommended that 44 undergo antiviral assay. Then we began using U.S. Department of Defense supercomputers to turbocharge this already powerful tool in the hunt for therapeutics.

SwRI is working with Iowa State University to develop a nasally administered coronavirus vaccine formulation for preclinical testing. SwRI is leveraging over 70 years of microencapsulation formulation expertise and our Current Good Manufacturing Practice-compliant capabilities to help develop a safe, effective COVID-19 vaccine using Iowa State's proprietary process and polymer.

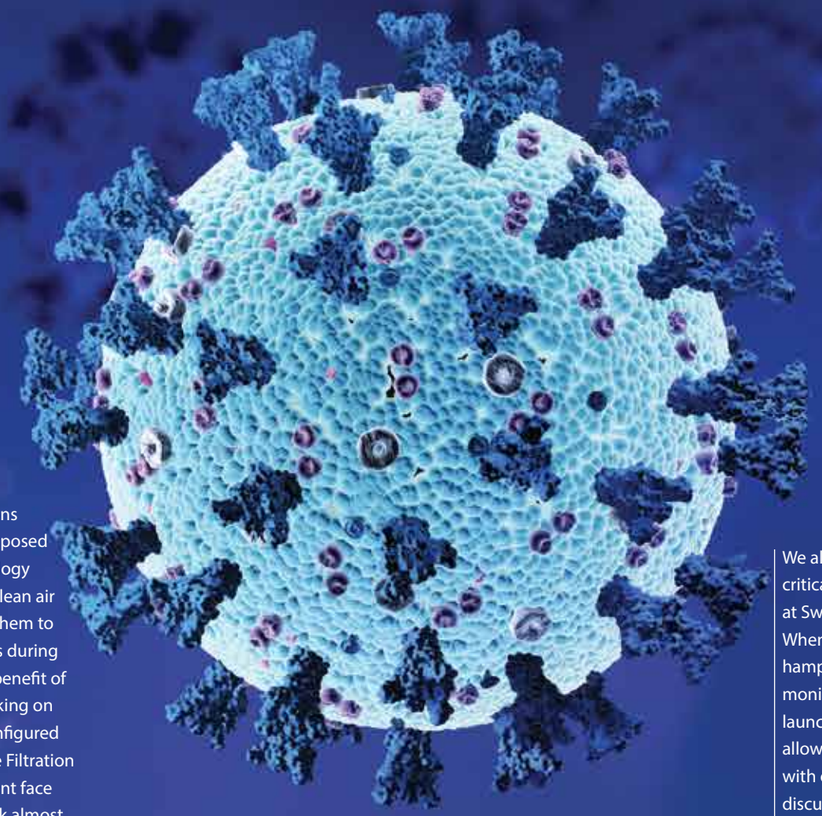
Through the San Antonio Partnership for Precision Therapeutics, we joined forces with Texas Biomedical Research Institute, UT Health San Antonio and The University of Texas at San Antonio on four collaborative programs to advance global COVID-19 intervention for early-stage antidotes and a potential vaccine. Our artificial intelligence experts also worked with these collaborators to frame infection dynamics of SARS-CoV-2 as a deep recurrent neural network, one of four models used by the city of San Antonio during the pandemic.

To address the shortage of medical supplies, the SwRI-operated South Central regional office of the Texas Manufacturing Assistance Center worked with regional nonprofits, government entities and businesses to launch the Medical Manufacturing Alliance of South Central Texas, aligning regional manufacturing supply chains with medical product demands.

To take cleaning crews out of harm's way, we are participating in an Advanced Robotics for Manufacturing Institute project to develop the Mobile Autonomous Industrial Disinfector (MAID), a robot system to perform surface disinfection for industrial workspaces. The collaborative multi-axis robot will be outfitted with a disinfection system and a sensor suite to identify areas that need cleaning, execute the disinfecting process and keep records of completed tasks.

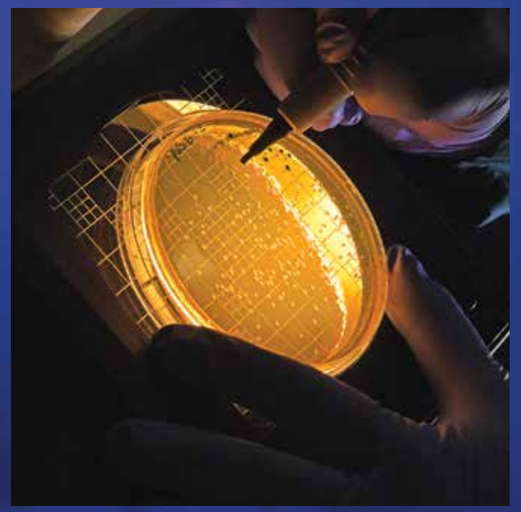
Microbiologists are investigating how to better prepare for future personal protective equipment, disinfectants and whole room disinfection needs.

Meanwhile, our emissions specialists rapidly repurposed techniques and technology developed to support clean air initiatives and applied them to address mask shortages during the pandemic. For the benefit of medical personnel working on the front lines, we reconfigured our Automotive Particle Filtration Lab to evaluate emergent face mask supplies. This work almost immediately discovered that eight out of 11 KN95 respirator samples were counterfeit and failed to meet the efficacy standards claimed on their packaging. Chemists also used our Floodlight™ and Searchlight™ software to assess chemical exposure from mask materials.



We also stayed vigilant toward critical client work in progress at SwRI when the pandemic hit. When stay-at-home orders hampered clients' ability to monitor their projects, we launched new techniques to allow them to stay in contact with our technical staff to discuss progress, problems and opportunities.

This Rhodium image shows possible therapeutics docked with the novel coronavirus protein, illustrating how the therapy could thwart disease processes.



ON THE COVER
SwRI's microbiological, biosafety level 2 lab quickly ramped up to support numerous programs addressing the COVID-19 pandemic, while maintaining support for advanced vaccine strategies, antimicrobial formulation screening, and disinfectant and antimicrobial technology assessments.

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PRESIDENT'S MESSAGE


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I am pleased to present the SwRI Annual Report for Fiscal Year 2020 (FY20), which will go down as one of the most unique years in the Institute's 73-year history. During the second half of FY20, as the COVID-19 pandemic raged, our staff and leadership proved to be particularly agile and adaptive as we continued to serve our clients, keep our employees as safe as possible and remain financially healthy.

FY20 began with a strong backlog of funding and contracts, and somewhat amazingly, it ended in much the same way. As the financial section of this report shows, our annual revenue and net income were modestly higher than the previous year, despite the tumultuous pandemic environment that began in February and continued through the second half of the fiscal year. Our workforce admirably adjusted to new working conditions and adapted operations for safety while finding new ways to support and communicate with our clients.

This issue of our Annual Report highlights our response to the COVID-19 crisis as well as the more traditional accomplishments that underscore the value of our unique multidisciplinary approach to solving complex problems and bringing promising ideas to fruition.

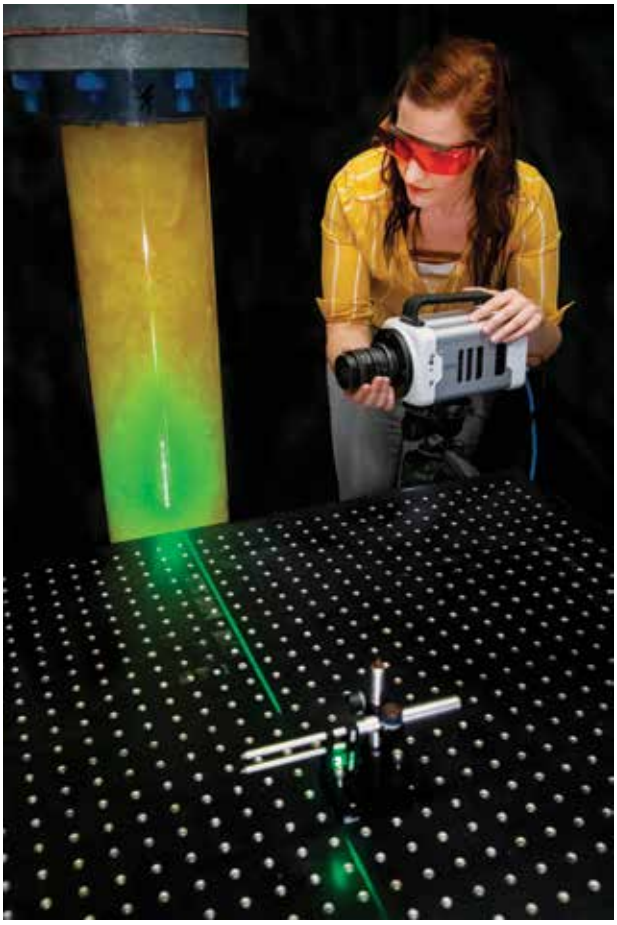
Our engineers and scientists are revolutionizing electric energy production by demonstrating new, more efficient supercritical carbon dioxide power cycles. In addition, a new five-year, $25 million contract with the Environmental Protection Agency funds conventional vehicle emissions and fuel efficiency evaluations, while we also advance electrified powertrain technology. We continue programs extending the service life of aging aircraft, as our advanced signals intelligence equipment safeguards those who defend our country. Our intelligent traffic technology is improving mobility and safety on the highways and byways of our land. And we are providing support for the development of new therapeutics and vaccines to protect humankind from COVID-19.

In addition, while solving some of the most difficult technical problems, the SwRI team responded to the severe human health and economic crisis generated by the pandemic with an outpouring of generosity. Our staff responded to calls for blood donations, school supplies, mask testing and many other tasks during the most difficult of times. Our record-setting contributions to the United Way demonstrated the extraordinary benevolence of our organization.

While uncertain national and international conditions and financial recovery models cloud the outlook for the coming fiscal year, we face tomorrow with renewed confidence born of our successful response to the challenges of FY20. Our backlog is at a record level, and our clients look forward to a return to full employment and capacity.

On a final note, near the close of the fiscal year NASA approved final assembly of the spacecraft for the SwRI-led Lucy mission, a 12-year voyage through the Solar System to explore Jupiter's Trojan asteroids, going, again, where none have gone before.

Adam L. Hamilton, P.E.
President & CEO



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Using fluorescent dyes to distinguish the elements of an oil-water-gas fluid, engineers used video image analysis to determine the mixture density of the comingled fluid, to better understand the concentrations of multiphase flows.

IR&D 2020

As a nonprofit research and development organization, SwRI uses part of our net income to invest in tomorrow's innovations, to broaden the Institute's technology base and to encourage our staff's professional growth. By funding internal research, we increase our technical capabilities, expand our reputation as a leader in science and technology and invest in technology our clients may need in the future. The program also allows engineers and scientists to continually grow in their technical fields by providing freedom to explore innovative and unproven concepts without contractual restrictions and expectations. IR&D is frequently cited as a key enabling factor leading to new projects, new clients and completely new research arenas within the Institute.

In 2020, SwRI initiated 114 new projects, investing more than $10 million in internal research, including quick-look and focused research programs. IR&D fulfills the Institute's objective of conducting innovative activities for the benefit of industry, the government and humankind.

D024203_9879

To expand our expertise in cyber resilience, cybersecurity specialists worked with automotive engineers to investigate whether electric vehicles could be vulnerable to cyberattacks during the charging process.

MILESTONES 2020

803
PAPERS PUBLISHED

284
PRESENTATIONS GIVEN

37
U.S. PATENTS AWARDED

31
U.S. PATENT APPLICATIONS FILED

48
INVENTION DISCLOSURES SUBMITTED

2,714
EMPLOYEES

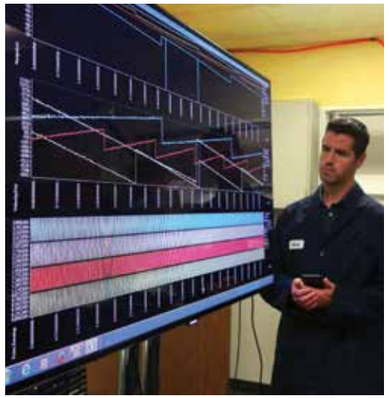
272
DOCTORATES

552
MASTERS

849
BACHELORS

240
ASSOCIATES

Two Southwest Research Institute-developed technologies won 2020 R&D 100 Awards. The first addresses how military planes use electronic countermeasure defense (ECM) systems to thwart enemy radar and deny targeting. SwRI developed the SPARTA system to evaluate ECM technologies, ensuring that they send the correct countersignal for a given radar cue. The second deals with stripping paint and other coatings from full-body aircraft, a costly, time-consuming and potentially hazardous process. The Laser Coating Removal (LCR) Robot, the world's largest robot system developed by SwRI engineers and XYREC, uses machine vision and intelligent processing to precisely and safely ablate aircraft coatings.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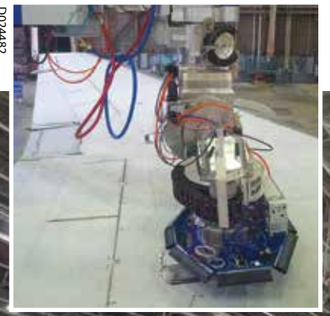
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IMAGE COURTESY BLUE ORIGIN

HONORS

Dr. Robin Canup: Co-chair, Planetary Science and Astrobiology Decadal Study for the National Academies of Sciences, Engineering and Medicine

Graham Conway: Editorial Board for Transportation Engineering

Walt Downing, P.E.: Institute of Electrical and Electronics Engineers Distinguished Lecturer and IEEE Aerospace and Electronic Systems Society President

Adam L. Hamilton, P.E.: Associate Fellow, American Institute of Aeronautics and Astronautics

Dr. Peter Lee: Elected as a Director of the Society of Tribologists & Lubrication Engineers

Dr. J. Hunter Waite: Presented the American Geophysical Union Shoemaker Lecture

AWARDS

Michael Quinn: National Association of Old Crows (AOC) Joseph W. Kearney Pioneer Award

Dr. Vicky Z. Poenitzsch: The Academy of Medicine, Engineering and Science of Texas (TAMEST) 2020 Protégé

C. Nils Smith: Stanley B. Hall Executive Management Award for AOC Dixie Crow Chapter

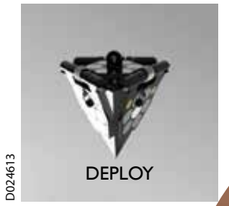
Dr. Danielle Wyrick: Ronald Greeley Distinguished Service Award, Planetary Geology Division of the Geological Society of America

New Horizons Mission: NASA Group Achievement Award and Sir Arthur Clarke Award from the British Interplanetary Society


D024611

In late 2020, SwRI conducted two microgravity experiments on Blue Origin's New Shepard rocket. Engineers tested a tapered liquid acquisition device (above) designed to passively remove problematic bubbles and safely deliver fuel from spacecraft storage tanks to the rocket engine, particularly important for long spaceflights.

Below, tetrahedrons with magnetized sides successfully gathered meteorite-like materials in low gravity, demonstrating how these small devices could passively gather asteroid surface materials and then turn themselves inside out to store the samples for transport.



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AUTOMOTIVE & TRANSPORTATION

Southwest Research Institute is involved in nearly every facet of automotive and transportation research, from powertrains to fuels and lubricants to intelligent highways, connected and automated vehicles, and hypersonic flight. We continue to invest in research to reduce greenhouse emissions and improve vehicle efficiency, including newer efforts in electrification and connected vehicle systems. We also research power systems, emissions and fluids for heavy-duty, locomotive, marine and aircraft engines.

SwRI's powertrain testing laboratory, the world's first lab qualified to evaluate greenhouse gases from hybrid-electric trucks, installed new dynamometers optimized for all-wheel drive and electric-powered trucks to better evaluate fuel economy and emissions.

DM24550_3567c

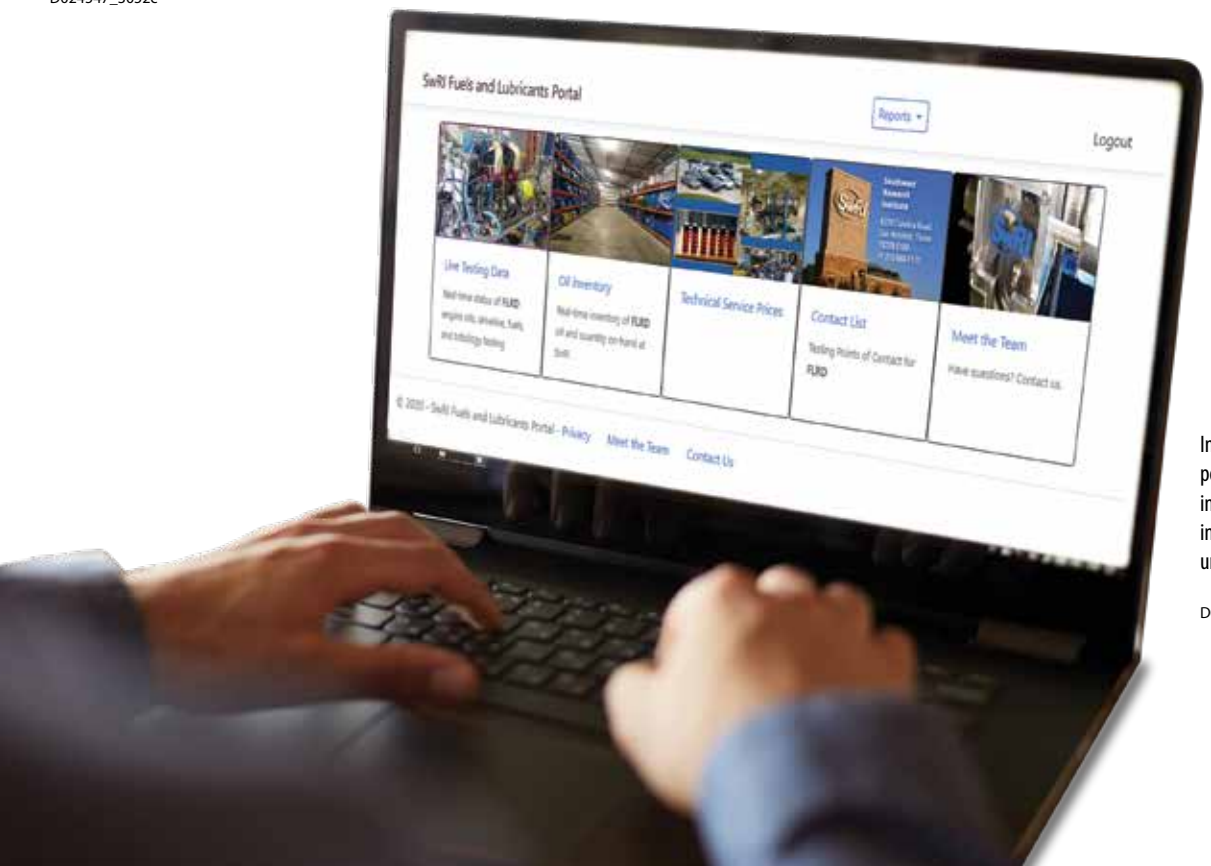
SwRI played a significant role in the development of the recently approved GF-6 lubricant specification, which certifies oils that will improve fuel economy while offering better protection for today's engines.

D024547_3052c

AUTOMOTIVE

For more than 70 years, SwRI has evaluated transportation functional fluids to meet certification standards. In 2020, we launched an online portal to provide our clients with increased access to information on the tests that we conduct for them. The portal enhances interactions with our clients and makes it easier for them to do business with us, offering a real-time snapshot of the hundreds of tests being run in SwRI labs. The improved client access to information was particularly useful during pandemic operations. For instance, SwRI clients could track the first rounds of testing to the new GF-6 lubricant specification completed this year. Motor oils that meet this specification will improve fuel economy while offering better protection for today's engines.

Meanwhile, we are investigating next-generation engine oils to understand how they can improve vehicle efficiency for proposed new standards. Currently, diesel engine oil specifications lack a standard test to measure lubricant-based efficiency, an area of particular importance to trucking companies, additive producers and oil marketers. If changing out the oil could improve vehicle efficiency by 1%, that could translate to millions of dollars in savings for fleet operators. SwRI has developed a variety of



In 2020, we launched an online portal to provide our clients with increased access to real-time information about test projects underway in SwRI labs.

D024623

lubricant-targeted efficiency bench tests that stringently control a variety of parameters while discriminating as little as a 0.1% efficiency difference between oils. As regulatory bodies around the world continue to tighten engine emission requirements, the market for precision efficiency testing for diesel engine oils will continue to grow.

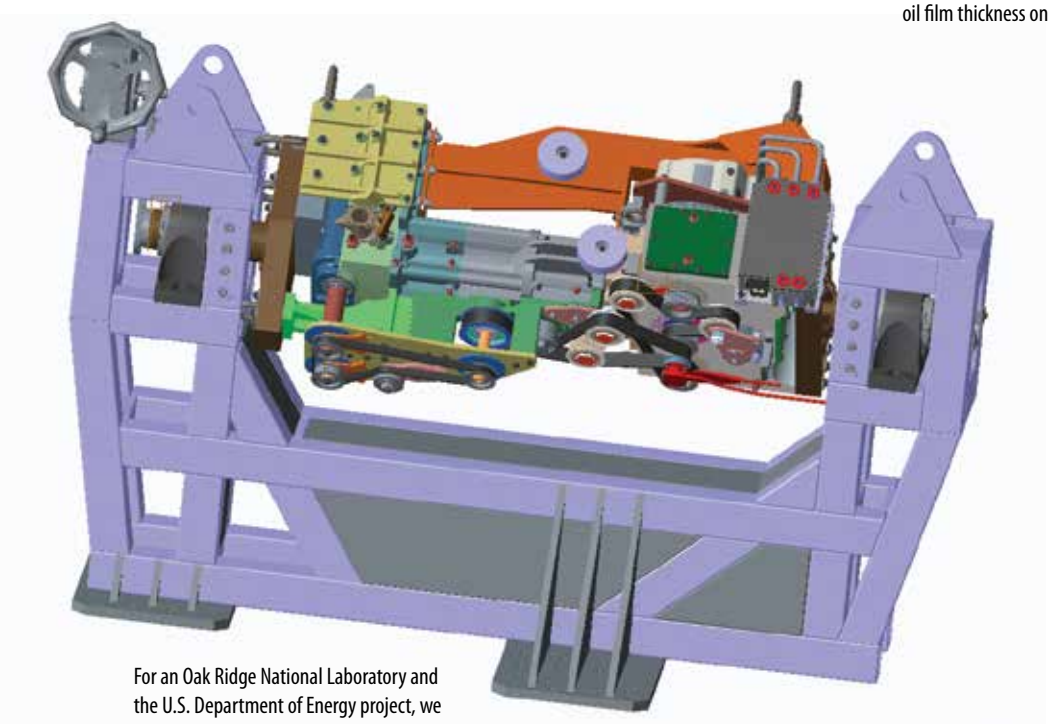
SwRI is home to a lab dedicated to tribology, the study of interacting surfaces in relative motion, which focuses on friction, wear and lubrication, particularly in automotive applications. We have developed faster, lower-cost tribology bench tests to screen lubricant products before proceeding to more expensive and lengthier engine-based qualification tests. This prescreening allows our clients to evaluate many more products with the same budget.

In the emissions arena, we expanded the capacity of our Exhaust Composition Transient Operation Laboratory — the ECTO-Lab™ facility — adding new lean-burn transient and stoichiometric test stands. These computer-controlled, multi-fuel burner systems simulate engine exhaust conditions to rapidly age a range of emission control systems and conduct steady-state and transient evaluations. We also expanded the capacity and capability of our Universal Synthetic Gas Reactor technology, which simulates real-world exhaust gas conditions to quickly and accurately characterize catalyst performance. Expanding catalyst testing capacity allows simultaneous testing, improves turnaround time and reduces costs.

One of SwRI's strengths is taking technology developed for one industry and creating new applications in another. For example, we are adapting supercritical CO_2 power cycle technology developed for the electric power generation industry for use with internal combustion engines to recycle waste heat and reduce transportation-related CO_2 emissions.

D024425_8325c

Engineers modified SwRI's bearing test rig to extend hybrid-electric testing technology from light-duty vehicles to heavy-duty trucks. The instrumentation precisely measures oil film thickness on the connecting rod bearings of heavy-duty engines.



For an Oak Ridge National Laboratory and the U.S. Department of Energy project, we modified our single-cylinder test engine to support probing the combustion chamber with a neutron beam.

D024624

In 2020, we adapted existing laboratory equipment to support client demands and the continuing shift of automotive engineering toward electric and hybrid-electric platforms. For instance, we modified our bearing test rig to extend hybrid-electric testing technology from light vehicles to heavy-duty trucks. As hybrid powertrains switch back and forth between the internal combustion engine and the electric motor, the frequent engine stops and starts can affect lubrication. These lubricants undergo unique cooling and heating cycles, creating different performance requirements than in traditional engine powertrains. Using internal funding, engineers designed the test rig to

D024573_4471c

SwRI developed this sophisticated open inverter, which runs any electric motor to OEM specifications without OEM support and can evaluate client parts or fluids for electrified powertrains on various hardware.

enable cutting-edge lubricant and bearing tests using multiple oil film thickness probes and an in-line torque meter to measure bearing performance.

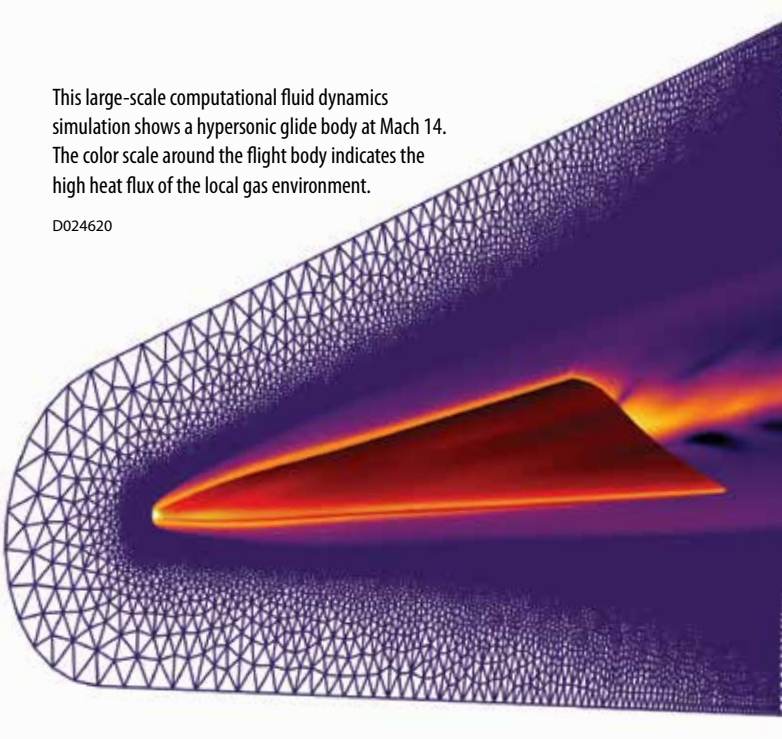
In addition to updating equipment, we also installed new chassis dynamometers optimized for all-wheel drive (AWD) and electric vehicles. These facilities perform mileage accumulation and durability testing as well as efficiency evaluations, necessary as vehicle fleets move toward more AWD and electric vehicle (EV) applications. We are also installing regenerative dynamometers that convert the mechanical energy from engine testing to electricity that can be returned to the Institute grid. This represents a modernization of capabilities, as well as a reduction in our energy consumption.

SwRI's powertrain testing laboratory became the world's first lab qualified to evaluate greenhouse gases from hybrid-electric trucks this year. These engines, although low in traditionally controlled emissions, still produce carbon dioxide gas. Reducing or even replacing engine operations with an electric motor can reduce CO_2 emissions. We are also investigating future hybrid concepts to make the internal combustion engine and the electric motor an integrated unit, where neither works well without the other.

In related research, engineers used internal funding to examine the unique demands that extremely high-rpm electric motors place on automotive fluids and the unique demands that EV powertrains place on lubricants. Many automakers currently use conventional fluids in electrified powertrains, which may not be optimized for the EV environment. The main concerns with EV fluids are electrical and thermal conductivity, corrosion, material compatibility, oxidation and extreme pressure performance.

At our Ann Arbor Technical Center, SwRI is testing the efficiency of electric vehicles by measuring voltage and current throughout the powertrain while simultaneously measuring torque and speed directly at the wheel hubs.

D024626



This large-scale computational fluid dynamics simulation shows a hypersonic glide body at Mach 14. The color scale around the flight body indicates the high heat flux of the local gas environment.

D024620

Additional critical features of electric and hybrid vehicles are their energy storage systems. SwRI operates a 12,000-square-foot Energy Storage Technology Center®, one of the largest state-of-the-art lithium ion battery and energy storage systems research facilities in the country. We provide the automotive and power generation industries with electrochemical energy storage and engineering expertise to research, develop and evaluate batteries, battery chemistries, battery cells and battery packs used in EVs and grid storage applications. Our energy storage research program is examining immersive coolants and fast-charging capabilities to improve hybrid-electric vehicle operation. Keeping batteries cool adds life and improves the power output of the electric vehicle's energy storage system, and rapid charging makes electric vehicles more competitive in the marketplace compared to easy-to-refuel gasoline and diesel vehicles.

In another hybrid vehicle project, an SwRI-led team demonstrated how connectivity and automation achieved a stunning 20% improvement in efficiency on a 2017 Toyota Prius Prime, a larger improvement than single-digit increases typically available to engine developers. The program met efficiency goals without changing the powertrain or compromising emissions, safety or drivability using new tools such as eco-routing, eco-driving and power-split optimization. Drivers using a navigation tool can set their destinations and see routes that may add minutes to their arrival time but are more fuel-efficient. While the technology is appealing to the eco-minded consumer, for delivery and service fleets, this 5–10% savings in fuel consumption can add up to millions of dollars in savings each year.

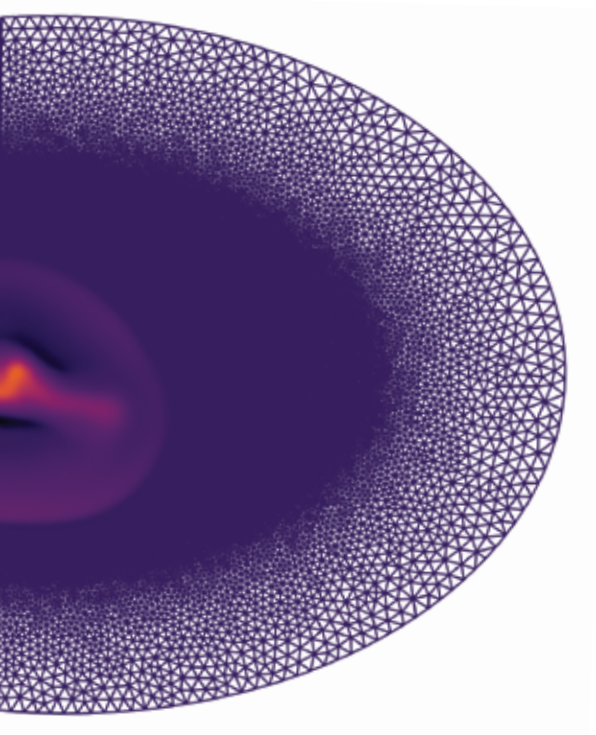
Using connected vehicle technology, SwRI engineers develop applications where traffic signal controllers and vehicles communicate via radios. The alert on this tablet warns drivers of a traffic signal change.

D024576_4670c

TRANSPORTATION

Connected vehicle (CV) technology is also a cornerstone for tomorrow's automated vehicles, which use sensor and localization technologies to navigate and maintain roadway position. SwRI fuses these technologies for diverse applications, from passenger cars to military vehicles designed to keep soldiers out of harm's way. Our work on the robotics technology kernel is helping to expand automation on military ground vehicles.

Connected vehicles communicate with the infrastructure and other vehicles to enhance mobility, safety and fuel efficiency. In 2020, we continued to support the installation of Georgia's comprehensive CV system in the Atlanta area, including dedicated short-range radios deployed at more than 400 intersections, with another 250 in progress and plans for over 1,000 more. SwRI is working with local agencies to develop a range of CV applications such as signal phase countdown, green speed recommendations, red light violation



SwRI expanded our radioactive tracer capabilities to make highly accurate real-time wear measurements for engine components.

D024548_3498c

warnings, and signal prioritization and preemption for transit vehicles and emergency responders.

Connected vehicle technology is often deployed via advanced traffic management systems (ATMSs) that help national, state, rural and municipal entities manage mobility, safety and environmental impacts from roadway traffic. Hundreds of billions of dollars are spent on the infrastructure every year; however, it's financially impossible to build our way out of congestion. Instead, 11 states and Puerto Rico use SwRI's ATMS technologies and services to help traffic flow more efficiently and safely. In 2020, SwRI used machine learning and computer vision algorithms to develop Active-Vision™ software to reliably detect wrong-way drivers in real time based solely on video from roadside cameras. Active-Vision software also tracks vehicle speed and precise GPS coordinates in real time and can detect changing weather conditions, incidents and other anomalies on the roadway.

In 2020, SwRI researchers used integrated corridor management solutions to improve traffic incident response through data fusion and analysis of third-party and crowdsourced data.

D024454_0491

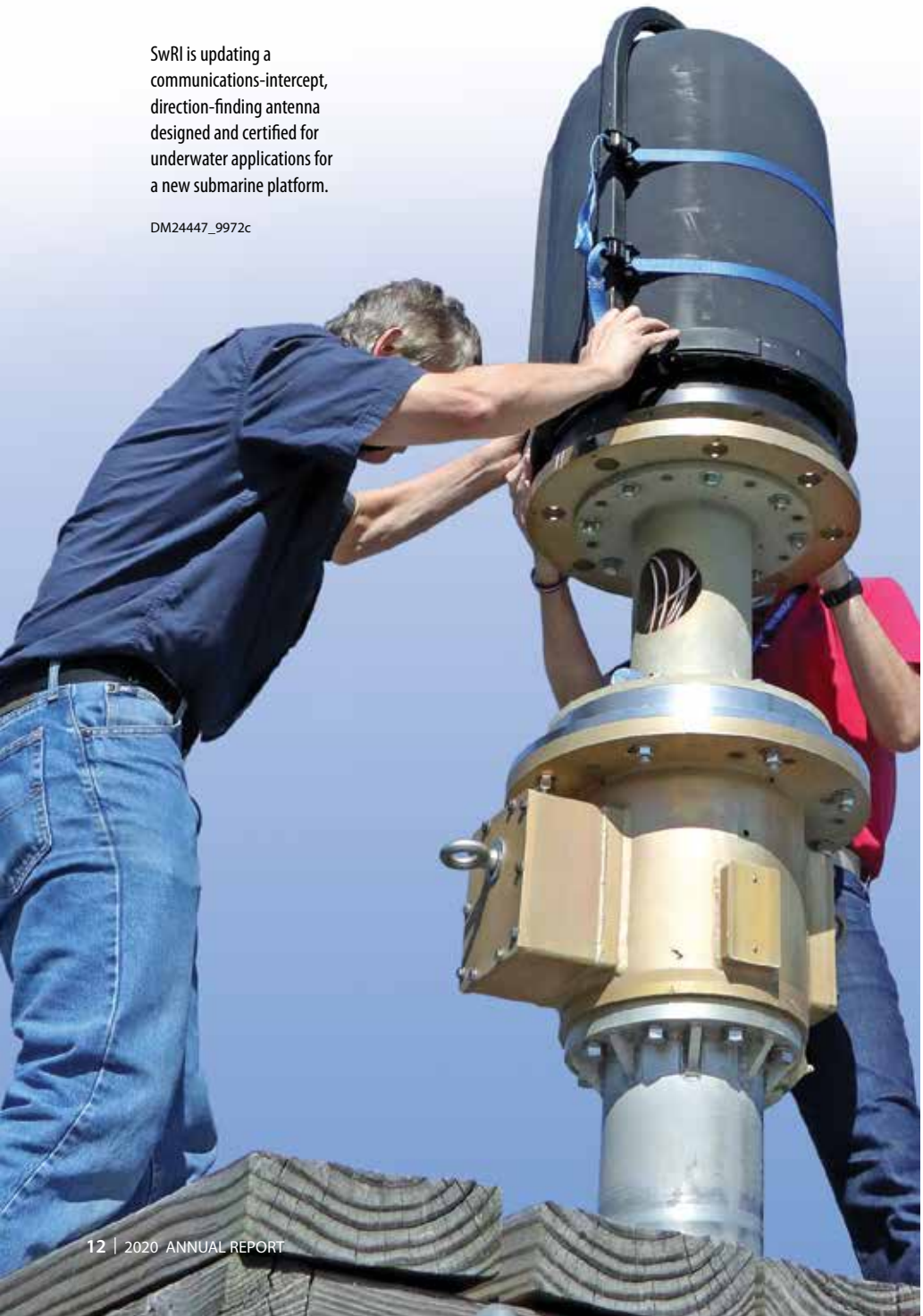
In 2020, the National Cooperative Highway Research Program and Transportation Research Board awarded SwRI projects to address cybersecurity concerns associated with transportation management systems. SwRI is researching the unique challenges that informational and operational technologies face to help guide state transportation agencies on cyber-incident management. SwRI is also helping improve automotive cybersecurity for commercial and military customers, developing techniques to secure over-the-air updates for vehicle firmware.

In other highway safety research, SwRI's onsite crash test facility recently added a median ditch to test cable safety barriers commonly used on divided highways to capture or redirect errant vehicles and prevent head-on collisions. Standards released in 2016 require cable barriers be tested in a ditch scenario.

In the aerospace arena, SwRI is using unique facilities and capabilities to explore how hypersonic vehicles traveling in excess of Mach 5 react to extreme heat and friction. We have machined and characterized carbon-carbon heat protection materials and improved fabrication techniques using probabilistic methods. Using our two-stage light-gas gun, we use advanced optical and spectral diagnostics to quantify the signatures of small-scale flight vehicles launched up to Mach 20. Using internal funds, we are expanding our NPSS® software for conventional aircraft engine simulations to hypersonic flight vehicles.

DEFENSE & SECURITY

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



SwRI is updating a communications-intercept, direction-finding antenna designed and certified for underwater applications for a new submarine platform.

DM24447_9972c

DEFENSE

Radio frequency (RF) surveillance and communications intelligence (COMINT), particularly using antennas and signals processing, are long-standing programs at SwRI. Signals intelligence (SIGINT) specialists help U.S. and allied militaries gather communications intelligence, fueling capabilities in electronic warfare (EW) that use electromagnetic techniques to thwart adversarial operations. SwRI supports EW techniques and technology to control the electromagnetic spectrum and deny advantages to an opponent, while ensuring friendly dominance of the spectrum.

SwRI is developing modular Ravager EW technology designed to maximize operational effectiveness and flexibility in response to emerging threats, while minimizing future supplier and parts shortages. We are integrating this advanced technology into legacy military EW systems, addressing size constraints and operational profiles of existing and future systems. SwRI engineers are currently developing and integrating Ravager proof-of-concept hardware and software into an existing military system.

SwRI continues to improve the Adaptive Threat Environment Acquisition (ATHENA) receiver, which rapidly detects all signals of interest, extracting signals from a single radar burst or in a congested or contested signal environment. In 2020, we added a 1-GHz receiver, improved signal identification algorithms and

expanded ultra-wideband capabilities for the hardware/software solution.

To monitor adversarial activities, intelligence operators use multiple individual tuners covering segments of the RF spectrum to survey the entire spectrum of digital communications. Configuring these resources offers great flexibility but can overwhelm operators. Using machine learning techniques, SwRI is automating tuner settings via reinforcement learning to meet intelligence goals in very- and ultra-high frequency (VHF-UHF) bands.

New maritime signal intelligence specifications require smaller packages for mobile platforms such as ships and planes. With internal funding, SwRI engineers developed a next-generation VHF-UHF signal processing architecture that combines communications and electronic intelligence capabilities in a single product, while reducing the system's size, weight and power. The new architecture increases instantaneous bandwidth for both signal detection and direction finding by an order of magnitude, increasing the probability of intercepting a range of radio frequency signals.

Processing analog voice signals is a major focus for maritime tactical SIGINT operations. SwRI is enhancing the graphical user interface for linguistic and translation applications while strengthening capabilities in speech processing, starting with language identification and progressing into speaker and keyword recognition.

We continued to expand our capabilities in long-range, high-frequency radio communications. We monitor global radio transmissions to gain insight into the state of the ionosphere, the layer of the Earth's atmosphere that reflects and modifies short-wave radio communications, to solve practical problems.

D024344_6883

While most of our research and development ends with demonstrating prototypes, SwRI is known worldwide for developing, producing, installing and servicing SIGINT technology, such as these antennas, used for various U.S. and allied military applications.

DM24539_1702c

Engineers completed a fuel-bladder test facility, equipped with a concrete floor and surrounding containment structure, to test military fuel bladders. These large portable containers store fuel for battlefield operations.

D024537_2252c

In 2020, engineers evaluated new antenna technology in our anechoic chamber. The SwRI-designed cylindrical slot array demonstrated high-quality omnidirectional output while also performing well as a DF array.

SwRI engineers evaluated onboard electronic countermeasure systems used to help the F-15 fighter aircraft elude enemy radar and targeting technology, recommending a new, advanced digital jammer for the aircraft.

SwRI engineers designed and developed a multi-channel, software-defined radio prototype with microservices architecture, which links small software functions to perform large, complex jobs — in this case, multiple simultaneous cyber, electronic attack, and communications and electronic intelligence tasks. SwRI will build a ruggedized product using modular, open-systems hardware architecture for installation on ships, aircraft and airborne pods.

To collect and broadcast signals, we used internal funding to develop a cylindrical, long-slot antenna array for mast-mounted installations, such as those aboard ships. SwRI's new design demonstrated high-quality, omnidirectional output while also performing well as a DF array. As a result, the Royal Canadian Navy has selected the new configuration, and SwRI will build a ruggedized product for shipboard installation.

The high demand for SIGINT and related services in 2020 drove expansions and updates to our antenna measurement facility, which included automating precision antenna measurements at extended frequency ranges.

SwRI also upgrades systems on aging aircraft platforms. For example, we are overhauling the B1-B Lancer's fuel center of gravity management system to support extending the aircraft's service life through 2040. The effort requires radiation- and electromagnetic-pulse-resistant hardware.

For 63 years, SwRI has hosted a government-owned, contractor-operated facility to provide advanced vehicle fluids research, development and engineering for the U.S. Army and other government agencies. The laboratory was renamed the U.S. Army Ground Vehicle Systems Center Fuels and Lubricants Research Facility this year. Notable accomplishments include enhancing our filtration evaluation facilities to provide cyclic flow and vibration testing to assure filters will work under the stresses of real-world operating conditions. We also completed a new fuel farm for testing military battlefield fuel bladders, large collapsible containers that can be airlifted to a forward site, filled from large fuel trucks and then used to supply fuel for tactical vehicles. The fuel-bladder test facility is equipped with a concrete floor and a surrounding containment structure. SwRI microbiologists are collaborating with fuels and lubricants specialists, evaluating the effectiveness of biocides in enhancing the stability of stored military fuels.

D024629

For more than 10 years, law enforcement organizations across the U.S. and Canada have used the SwRI-developed Digital Automotive Image System (DAIS) to investigate crimes involving motor vehicles.

As one of the world's largest organizations dedicated to fire technology with more than 30 years of research supporting chemical weapons destruction activities, we initiated the "Bolsa Caliente" research program for the U.S. Department of Defense in 2020. This program uses a specially insulated lightweight bag and thermite to safely destroy contaminated uniforms and other items exposed to chemical agents on the battlefield.

SECURITY

Understanding risks and protecting computer-based systems is of concern to the military, businesses and individuals alike. SwRI specializes in both physical and cybersecurity applications for the military, as well as addressing cyberthreats to intelligent vehicles and transportation systems.

SwRI engineers are studying 5G network core and security applications to develop new global geolocation and "geo-enabling" infrastructure. The techniques use geographic information as part of non-location-related activities to update and support critical networks and information exploitation functions.

In 2020, SwRI made a sixth update to the Digital Automotive Image System (DAIS). Since 2007, thousands of law enforcement organizations across the U.S. and Canada have used this software tool to investigate crimes involving motor vehicles. DAIS helps identify vehicles seen by witnesses or captured by video cameras at a crime scene, using SwRI-developed algorithms. Updates provided this year increase the characteristics that can be searched to aid with investigations.

D024426_8738c

SwRI is testing a client's compressed air foam delivery equipment designed to optimize the performance of new environmentally friendly fire-suppressing foams for the military.

EARTH & SPACE

Southwest Research Institute is home to one of the nation's leading space science and engineering programs, developing innovative technology and conducting fundamental and applied research for commercial companies and national and international agencies. Our staff leads missions, investigates space phenomena, and develops payload instruments, electronics and spacecraft. Earth science expertise complements our space research.

In 2020, an evolution of the CYGNSS suitcase-sized satellites, shown here under test, was added to NASA's Rapid Spacecraft Development Office IV catalog used by the U.S. government to easily contract for proven spacecraft.

DM21879_9794

SwRI is home to principal investigators for five active NASA missions, including the Polarimeter to UNify the Corona and Heliosphere (PUNCH), Magnetospheric Multiscale (MMS), Juno, New Horizons and Lucy missions.

PUNCH, which is scheduled to launch four microsatellites into polar orbit in 2023, will image the region where the Sun's outer atmosphere transitions to create the solar wind, a supersonic stream of particles that fills the Solar System. MMS is continuing its study of magnetic processes that drive auroras and other energetic events in the Earth's magnetosphere, while New Horizons journeys across the Kuiper Belt as the mission team searches for another possible flyby target. The Juno mission to Jupiter is on the home stretch of its primary mission. The spacecraft and its instruments remain healthy, paving the way to a possible mission extension with an additional focus on Jupiter's moons.

The Lucy team is integrating instruments with the spacecraft in anticipation of an October 2021 launch, beginning a 4-billion-mile journey to explore the Trojan asteroids, a population of ancient small bodies that share an orbit with Jupiter. Lucy will fly by

D024619

SwRI manufactured, tested and delivered the Lucy-Ralph Multispectral Visible Imaging Camera, which will take high-resolution images of Jupiter's Trojan asteroids.

seven of the Trojan asteroids, plus a main belt asteroid, allowing it to survey the diversity of this population in a first-ever, record-breaking mission.

Engineers continue to develop and promote advanced avionics and processing capabilities for spacecraft in Earth-orbit and deep space applications, including providing the Rendezvous and Docking Avionics for the Mission Extension Vehicle-1. Our system played a crucial role in a historical first, when two commercial satellites docked in orbit to extend the service life of a satellite running low on fuel.

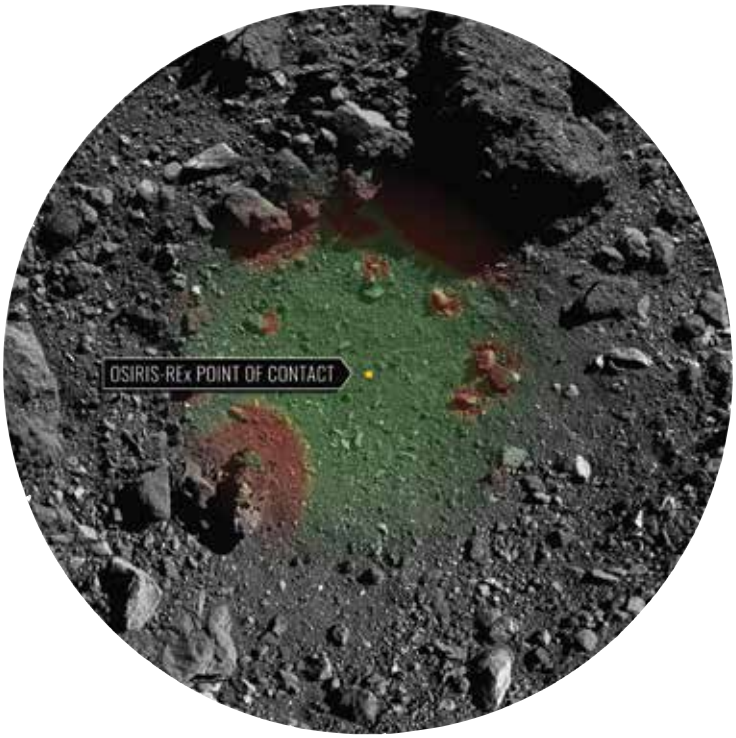
SwRI space scientists and engineers designed, built and delivered the Ultraviolet Spectrograph (UVS) for the European Space Agency's JUICE mission to Jupiter. They are also developing the UVS and MAss Spectrometer for Planetary EXploration (MASPEX) instruments for NASA's Europa Clipper mission as well as scientific instruments for various solar-related missions. Scientists also support various asteroid and lunar investigations as well as research and modeling of Solar System and planetary formation.

In 2020, SwRI developed advanced machine learning and artificial intelligence algorithms with the potential to substantially reduce space mission costs by optimizing the data stream transmitted back to Earth while enhancing how distant spacecraft interpret sensor data and independently respond to changing conditions.

Closer to home, NASA has extended the Cyclone Global Navigation Satellite System (CYGNSS) mission for another three years. From low-Earth orbit, the constellation of microsatellites designed, built and operated by SwRI penetrates thick clouds and heavy rains, accurately assessing wind speeds to better understand hurricane intensification over oceans as well as studying flooding and subsurface moisture on land.

SwRI continues its long history of solving liquid propellent challenges for the launch vehicle industry. In 2020, we helped the commercial space industry solve problems with slosh dynamics, liquid acquisition devices and tank pressurization systems. In addition to certifying equipment that avoids potentially devastating pulsation interactions between the propellant system and the launch vehicle structure, we have improved models that predict propellant temperature throughout the tank. With this, engineers can better predict liquid hydrogen boil-off to improve tank pressurization controls throughout the mission.

IMAGES COURTESY NASA/JAMIE ADKINS AND NASA/UNIVERSITY OF ARIZONA



SwRI scientists helped select the location for NASA's successful sample collection feat from the surface of asteroid Bennu. We also used OSIRIS-REx data to understand more about the near-Earth asteroid's history and makeup. The asteroid sample will return to Earth in 2023.

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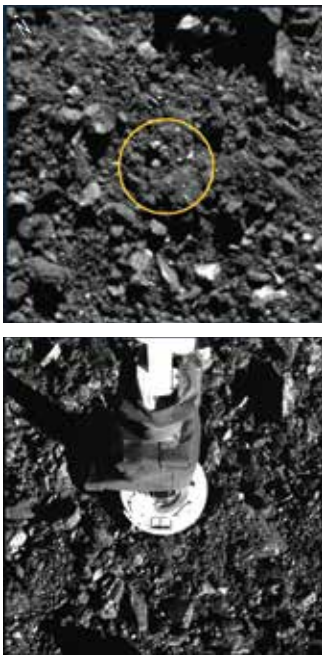

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ENERGY & ENVIRONMENT

Energy fuels the global economy, and Southwest Research Institute is a leading provider of technical solutions that improve the efficiency, reliability, safety and impact of energy, from electric power plants to oil and gas production to nuclear and renewable resources. Comprehensive environmental services complement our work in the energy field.

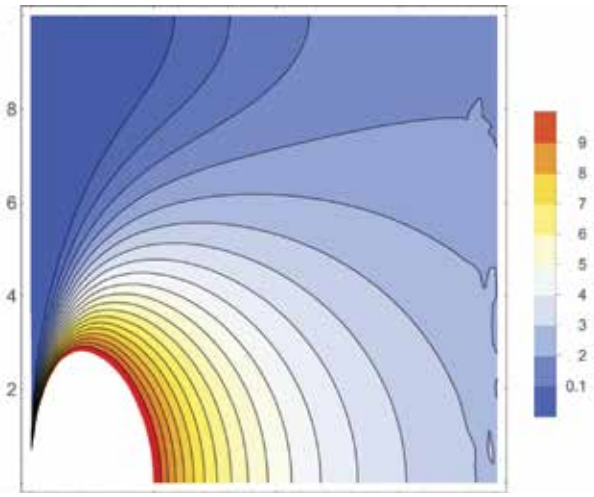
SwRI expanded its fuel blending facilities, which can now produce batches of up to 10,000 gallons of materials such as crude oils, biofuels, distillates, heavy oils and client-specific feedstocks.

DM24183_7004

ENERGY

SwRI continues to develop technologies to advance power systems for the oil and gas and electric power industries. This year we will commission the 10 MWe Supercritical Transformational Electric Power (STEP) pilot plant, which demonstrates component and system technologies for supercritical carbon dioxide (sCO_2) power cycles. We are demonstrating smaller MW-scale test rigs for large turbine seals, advanced compressor-expander architectures and oxy-fuel combustion for a zero-emission direct-fired sCO_2 cycle. We also develop grid-scale energy storage technologies in collaboration with commercial companies and the U.S. Department of Energy.

Since 1987, SwRI has operated the Center for Nuclear Waste Regulatory Analyses (CNWRA®) to assist the Nuclear Regulatory Commission (NRC) with regulatory responsibilities associated with radioactive waste storage, transportation, disposal and related areas. This year, CNWRA staff completed two draft Environmental Impact Statements for long-term consolidated interim storage facilities for spent nuclear fuel, and studied transportation, storage and disposal aspects of the various types of nuclear fuel used in advanced nuclear power reactors.



SwRI is enhancing its radiological dose model to incorporate radon inhalation pathways. The plot shows the airborne concentration of radon released from underground disposal of radium-bearing waste.

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In 2020, SwRI completed construction of the STEP sCO_2 pilot plant building. We are now installing reconfigurable skid-mounted components, which allows the facility to evolve and keep pace with advancing technology.

Scientists and engineers also evaluated the operational risk that seismic and volcanic hazards pose for nuclear power plants and continued assisting the NRC in license renewals for nuclear material storage and transportation. We also integrated existing models to efficiently explore complex coupled hydrologic, thermal and mechanical processes in deep geologic repositories.

SwRI engineers and scientists develop and validate novel processes to upgrade and refine hydrocarbon products using custom catalysts, pilot plants and laboratory facilities. SwRI is a leader in developing fuels from unconventional sources, producing biofuels that meet Environmental Protection Agency standards. SwRI has expanded its capacity to develop and certify fuels from alternative sources with a novel fixed-bed reactor that produces stable fuels ready for vehicle use.

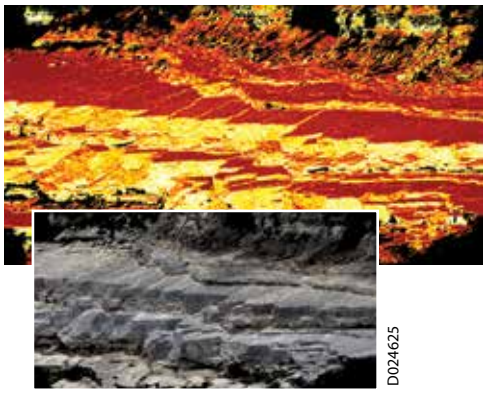
In addition, SwRI provides exploration and production support to oil and gas companies, using a range of applications in structural geology and geomechanics. SwRI is developing new drone-based, remote-sensing techniques to digitally map and model exposed geologic structures to better understand subsurface formations associated with petroleum and water reservoirs.

ENVIRONMENT

In 2020, SwRI chemical engineers entered a new arena, supporting industry and government initiatives to address the global glut of plastic waste with new recycling techniques. With over 15 years of pyrolysis process development experience for the energy industry, SwRI is helping clients develop commercially viable technologies to convert plastics into useful chemicals or fuels. In addition to this "circular economy" for plastics, SwRI is investigating the gasification of plastics in its extensive pilot plant facilities with the goal of producing hydrogen as a low-carbon fuel.

Water quality and availability remain important global and local concerns. SwRI developed an integrated hydrologic computer model to evaluate the impact of different types of wastewater disposal facilities on the Edwards Aquifer, the primary water source for San Antonio and surrounding communities.

D024622



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D024625

Through digital photogrammetry — reconstructing real-world objects in 3D from overlapping digital images — SwRI can extract accurate and reliable subsurface geologic information from drones flying over surface structures such as outcrops.

MANUFACTURING & RELIABILITY

Southwest Research Institute supports the manufacturing industry with advanced automation technology, creating adaptable tools while providing workforce training. We also help ensure that aging infrastructure and new construction products meet or exceed standards for safety, durability and performance.

SwRI automation and nondestructive evaluation engineers demonstrate how a custom mobile robot navigates a tight spot to ultimately evaluate the integrity of double-wall storage tanks that hold chemical and nuclear waste.

DM24563_4248c

MANUFACTURING

In the field of manufacturing automation, SwRI has pioneered using the Robot Operating System (ROS) to advance manufacturing with the ROS-Industrial (ROS-I) open-source project. For the past seven years, we've led the ROS-I Consortium through global collaborations in Europe and the Asia Pacific region. In 2020, we developed several projects with ROS2, the newest version of ROS. We have also applied ROS-I in a wide range of industrial processes, including automotive and aerospace applications, automating path planning to paint or sand a wide range of components.

In 2020, SwRI celebrated 25 years of operating the South Central regional office of the Texas Manufacturing Assistance Center (TMAC), serving 159 manufacturing companies in the area this year.

RELIABILITY

In the U.S. and abroad, manufacturing and construction projects ranging from bridges to pipelines to aircraft are nearing, or have surpassed, their original design lives. Because this infrastructure is considered too costly to replace, SwRI offers a portfolio of test technology, fitness-for-service and potential life extension solutions for these aging systems. Over the past 40 years, SwRI has become internationally recognized as one of the world's leading independent aerospace structural integrity and testing

laboratories supporting commercial and government clients. We conduct component and full-scale structural static, fatigue, vibration and impact tests, including bird strike simulations. We use computer-aided design and finite element analysis tools to design complex test fixtures, ensuring accurate test loads and enforcing proper boundary conditions.

Our Aircraft Structural Integrity Program (ASIP) conducts aircraft usage monitoring, structural analysis, testing and non-destructive inspections. Integrating this ASIP information allows the Air Force to manage the risks of operating its aging aircraft fleet. New aircraft data recorders track A-10 usage, while laboratory testing determines basic material properties and damage tolerances. We conduct component and full-scale testing and analysis and use our patented magnetostrictive sensors to assess the structural health of the A-10.

Recent improvements to the CH-47 helicopter include the addition of an advanced actuator. SwRI is updating, validating and verifying depot maintenance work requirements for the device, including functional and environmental stress screening (ESS), which exposes manufacturing defects using thermal and vibration stresses during operation. SwRI is modifying the rotary electric test stands to accommodate functional testing of the new actuator, designing and building instrumentation to monitor the device during ESS testing, and performing the temperature and vibration tests required.

For military aircraft engines, SwRI is developing a flight line system to test T5 amplifier system components for the J85 turbo-jet engine that powers the T-38 and F-5 aircraft. The tester will evaluate the T5 under both static and dynamic engine states. Currently these components require removal for testing. SwRI is designing and prototyping a portable test system to isolate faults on-engine so the unit is only removed and replaced when necessary.

SwRI continues to upgrade the Engine Tracking Database System (ETDS), which helps friendly foreign militaries around the world support and maintain the F110 engines used in F-15 and F-16 aircraft. The ETDS program facilitates tracking and management of parts, maintenance, usage and inspection data for the F110 family of engines. Seven allies currently use the system, with additional countries coming online soon.

SwRI continues to improve the DARWIN® probabilistic fracture mechanics tool used to design and certify aircraft engines, most recently to address a nickel disk fracture that caused an engine to catch fire.

In addition, SwRI engineers are developing and using our NASGRO® and NESSUS® software to evaluate the fitness-for-service of NASA's aging ground-based pressure vessels. Since 2014, SwRI has enhanced the NASGRO fracture mechanics and fatigue crack growth software to enable NASA to manage its aging layered pressure vessels.

D024028_3186

This complex custom test stand evaluates the structural integrity of Next Generation Jammer pods under real-world conditions. The pods are installed on EA-18G Growler aircraft to thwart enemy radar and targeting systems.

DM24564_3920

SwRI engineers are developing a fully automated tractor system for vineyard operations management. Multi-sensor data fusion perception systems interface with the autonomy kit to support path planning and navigation.

CHEMISTRY & MATERIALS

Chemicals and materials affect our everyday lives, from the products we use to the foods we eat to the homes we occupy. Southwest Research Institute works with our clients to address difficult technical challenges to improve product and material safety and performance, including applying artificial intelligence techniques to improve the research results from chemical assays.

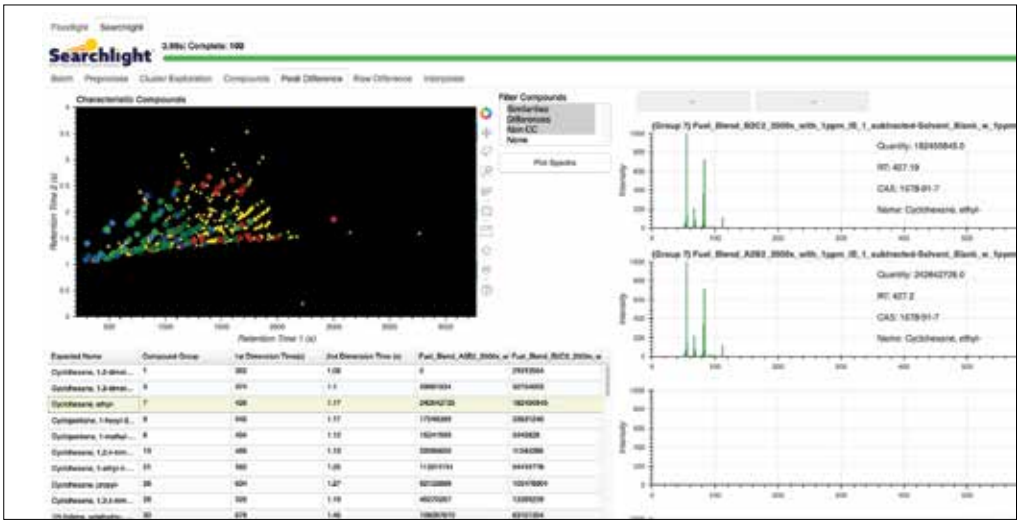
Our staff members are pioneers in chemical and process engineering, microencapsulation, fire technology, chemical analyses, material sciences and surface engineering.

SwRI has developed Floodlight™ and Searchlight™ software tools that increase throughput and depth of chemical analyses to characterize the chemical components present in food, drugs and other products. Floodlight software uses artificial intelligence to separate the signals from the noise, providing data quality review at accuracies comparable to human experts. Searchlight software employs end-to-end automated processing and data-driven pattern analyses across sample sets to provide interactive decision support, highlighting chemical fingerprints for interpretation by chemists.

D024552_8131

SwRI develops surface engineering processes to modify material properties and improve performance. For instance, some coatings repel water or material buildup on equipment ranging from pipelines to aircraft to food processing equipment.

In this example, the SwRI-developed Searchlight tool uses spectroscopic data, pattern analyses and machine learning algorithms to create interactive visualizations of the components present in fuel samples.



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BIOMEDICAL & HEALTH

Southwest Research Institute supports the healthcare industry, providing biomaterials and pharmaceutical development as well as food safety and microencapsulation research. We are leveraging our 70 years of experience in microencapsulation to meet client needs in pharmaceutical, veterinary, food, nutraceutical, agricultural and consumer products.

Our microbiology and drug development teams are collaborating with the University of Texas at San Antonio (UTSA) to develop a vaccine that protects against a potential biothreat associated with the bacteria Francisella tularensis, which causes tularemia or "rabbit fever." To support human clinical trials, SwRI is formulating an intradermal injection using a UTSA-developed, genetically modified subspecies that offers protection against the bacteria. The goal is to develop a vaccine formulation that protects humans from tularemia for up to a year. SwRI is improving vaccine stability through chemistry manufacturing controls and using slow-release encapsulation formulations to extend immunity.

SwRI scientists continue to develop antidotes for chemical warfare agents, particularly neurotoxins that attack the central nervous system. In 2020, this Department of Defense research expanded to include investigations into using enzymatic hydrolase as a countermeasure.

SwRI has numerous facilities to help government and industry assess and address the health and safety of the public. Our microbiological, biosafety level 2 lab quickly ramped up to support numerous programs addressing the COVID-19 pandemic, while maintaining support for a range of research and standardized testing. Some of these programs advance vaccine strategies, screen antimicrobial formulations and assess new disinfectants and antimicrobial technologies.

We continue to advance SwRI-developed cell expansion bioreactors technology and its use in regenerative and personalized medicine. With the support of multiple government contracts, we developed different-sized bioreactor systems to manufacture stem cells and stem-cell-derived therapeutic products. In 2020, we improved bioreactor durability and performance to cost-effectively manufacture large volumes of chimeric antigen receptor T-cells for cancer therapy.

DM24406_0109c

SwRI expanded its microencapsulation capabilities, adding an advanced electrostatic spray drying system that supports low-temperature production of heat-sensitive or volatile active ingredients, from small molecules to biologicals.

SwRI is collaborating with UTSA to develop a novel, intradermally administered vaccine formulation that provides long-term protection against a potential biothreat. Here, microbiologists capture digital images of cultures of gram-negative-stained genetically modified bacteria.

DM24533_1951c

FINANCIAL HIGHLIGHTS

STATEMENTS OF FINANCIAL POSITION | in thousands of dollars

	For the year ended September 25, 2020	For the year ended September 27, 2019
Current Assets	$417,628	$396,206
Property & Equipment, Net	309,238	278,335
Other Assets	93,611	87,417
Total Assets	$820,477	$761,958
Current Liabilities	$121,446	$103,823
Noncurrent Liabilities	70,142	66,655
Net Assets	628,889	591,480
Total Liabilities and Net Assets	$820,477	$761,958

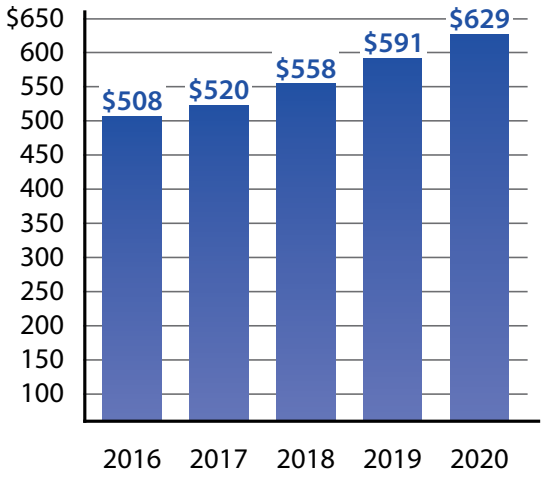
Consolidated revenues hit a record high at nearly **$696** million — up over **3%** from 2019

Consolidated net income from operations was **$36.8** million — up **7%** from 2019

Capital expenditures exceeded **$59** million — up **145%** from 2019

Internal research spending reached a record high of **$10** million — up **24%** from 2019

NET ASSETS | in millions of dollars



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COMMUNITY CONTRIBUTIONS

In 2020, Southwest Research Institute continued its long history of support to the San Antonio community, including contributing more than $1.2 billion to the local economy. Our 2020 United Way campaign raised more than $1 million for the first time, one of only eight local organizations to reach that level. We also held an extra United Way drive to provide additional support to organizations serving the community during the COVID-19 crisis. To protect our staff and the community, SwRI minimized the number of people working onsite and adjusted schedules and worksites to meet CDC guidelines.

Staff members continued to volunteer with local agencies, but on a more individual basis as organizations such as Meals on Wheels and the San Antonio Food Bank changed operational protocols. As blood supplies fell precipitously low, SwRI responded by increasing the number of blood drives on campus to once a month. In 2020, our staff members donated 1,035 pints of blood. In addition, the staff raised $425 in cash and donated 22 boxes of school supplies for local students in need. As the year came to a close, the staff donated five boxes of gifts for the Marine Toys for Tots program.

SwRI staff are also conducting local research programs. For example, we deployed a LIDAR sensor system on garbage trucks, automatically detecting potholes on San Antonio streets to more effectively streamline road repair services. Engineers will use the LIDAR data in conjunction with a camera to train a machine learning algorithm to detect the potholes with a lower-cost sensor.

Amid the nationwide shutdown due to COVID-19, the lack of universal digital network access became apparent, particularly as it affected distance learning. In the San Antonio area, Southwest Independent School District (SWISD) discovered that 11% of its students had inadequate broadband access to support its digital learning efforts. In response, Bexar County contracted SwRI to develop a private wireless network to support rural and underserved students. SwRI will implement a pilot program solution to serve areas of SWISD, which could later expand to other Bexar County school districts.

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