Since 1947, Southwest Research Institute has served as an independent, nonprofit research and development organization helping government and industry clients solve complex problems. Operations began on donated ranchland west of San Antonio, Texas, with early efforts focused on automotive testing, environmental research and radio direction finding. SwRI today occupies more than 1,200 acres and provides more than 2 million square feet of laboratories, test facilities, workshops and offices. SwRI’s research program includes materials research, space science, emissions research, field services for the oil and gas industry, microencapsulation, and much more.
The Institute’s new gate and entrance, complete with attractive landscaping and electronic features to help secure our grounds, is just one component of the infrastructure we have improved to better support clients and staff.
This year, our staff were responsible for innumerable achievements and discoveries, enabling more advanced science and applied technology solutions for our clients’ most important and pressing problems. By maintaining our relevancy in an ever-changing world, we have again added to the long and successful history of Southwest Research Institute (SwRI). For nearly 70 years, the Institute has solved some of the most challenging technical problems facing humankind, and answered questions regarding the breadth and depths of our planet as well as the very nature of the universe. Our success has provided results, both visionary and practical, for people around the world. The SwRI “family” has enriched the lives of those around us in every office and on practically every continent.

I am deeply honored to be the fourth president in SwRI’s storied history and feel privileged to witness firsthand, every day, the dedication of our talented scientists, engineers, and staff members. We remain committed, as we have since the day the Institute was founded, to working collaboratively to provide solutions for some of the world’s most challenging scientific and engineering problems. This annual report highlights just a few of the many expansive programs and staff accomplishments from 2014.

We currently have 10 divisions working on a wide array of applied R&D initiatives, and in this diversity lays our strength. We have a balanced portfolio — currently Institute projects are split approximately 55/45 percent between government and commercial clients — so we can maintain a robust workload despite potential downturns or setbacks in a particular sector or industry. Although this past fiscal year was not without its challenges, together with our government and industry clients we continue to share a common vision to advance science and technology.

Our Dedicated EGR® engine technology has now been proven to be more efficient and significantly reduces fuel consumption. This innovation was recognized with an R&D 100 Award as one of the 100 most significant technological achievements of the year. The Dedicated EGR® (D-EGR®) engine technology is a prime example of how the Institute’s industry consortia programs can be a conduit to further develop innovative technology. The D-EGR technology was conceived through the High-Efficiency Dilute Gasoline Engine (HEDGE®) program, now in its third iteration, and later funded through our internal research and development program to refine the technology that is more efficient and helps reduce fuel consumption. It won a 2014 R&D 100 Award from R&D Magazine as one of the 100 most significant technological achievements of the year.

Intelligent transportation engineers are developing a regional advanced transportation management system in northern New England to make traveling in that part of the country safer. Our space scientists were a part of the Rosetta team that sent the first spacecraft to orbit and then position a lander on a comet. Scientists refined the chemistry necessary to help a San Antonio plant convert carbon dioxide emissions to marketable products. The Electric Reliability Council of Texas selected the Institute to develop and deploy a new vehicle-to-grid aggregation system that both charges vehicles and returns electricity to the grid.

We continue to work closely with clients to better serve industry as a whole and initiated several new consortia to advance industry concerns. The Advanced Combustion Catalyst and Aftertreatment Technologies, the Advanced Engine Fluids, and the Dynamic Bearing Rig consortia all are designed to assist original equipment manufacturers meet new guidelines and address specific problems in the automotive industry. We launched the joint-industry Separation Technology Research Program to better understand oil and gas separation technology. And the Institute is part of a team working to modernize the U.S. Air Force’s A-10 Thunderbolt aircraft under a four-year structural integrity program.

We also continued to invest in our infrastructure and facilities, including a high-horsepower engine dynamometer with state-of-the-art emission controls to evaluate engines up to 7,000 horsepower for transportation, pipeline, and power generation applications; additional deep water ocean chambers for high-pressure, high-temperature testing for the oil and gas industry; and a more than 11,000-square-foot facility to...
fabricate and test large, heavy components to enhance service and research capabilities for oil and gas, aerospace, marine, and industrial clients.

The multi-faceted expertise of our scientists and engineers continues to gain worldwide recognition. Last year our technical staff published more than 600 papers and gave more than 500 presentations at various industry conferences and academic colloquia. Our highly trained staff totaled 2,771, with 294 holding doctorate degrees, 508 master’s degrees, and 700 bachelor’s degrees. In 2014, staff members were awarded 73 patents, filed 42 patent applications, and submitted 54 invention disclosures.

The Institute remains committed to helping our community through outreach opportunities and contributing expertise and experience. The Institute was one of three San Antonio organizations to receive a 2014 Partner of the Year Award from the Northside Independent School District. SwRI employees donated school supplies to benefit at-risk youth in San Antonio’s school districts. Hundreds of Institute employees and family members participated in the SwRI Cares program in conjunction with SwRI’s United Way campaign. And the Institute assisted in establishing a display at the Challenger Learning Center at San Antonio College that highlights the contributions of staff members to numerous space programs.

Exploring innovative ideas enriches our science and technology base. Internal funding for research and development provides opportunities to explore innovative ideas and develop potential solutions to problems. We initiated 73 new internal research and development (IR&D) projects in 2014 and expended $6.9 million. Many of these are described throughout this report.

We remain committed to expanding our technical strengths and resources to meet strategic and fiscal goals. In 2014 our technical programs generated revenues of $549 million, with net income of nearly $8 million. Total payroll was more than $226 million. Our large backlog of contracts and proposals is an encouraging sign for a successful 2015.

I appreciate the Board of Directors support for the Institute and look forward to working with them in my new role as President, as well as with the Advisory Trustees and Institute staff to ensure that our clients continue to receive the highest quality scientific and technical services in 2015 and beyond.

Respectfully submitted,

Adam L. Hamilton, P.E.
President
Since 1947, Southwest Research Institute has developed an array of tools, services, and facilities to design, improve, or evaluate virtually every component of on- and off-road vehicles, as well as stationary power equipment. Exceptional quality and a focus on client needs characterize our efforts in engine design, fuel economy, fuels and lubricants, and emissions reduction.

The newest generation of gasoline engines, direct-injected spark-ignition engines, is significantly more fuel efficient than its predecessors. However, some high-performance engines have encountered lubricant durability issues. To counter these effects, manufacturers are reformulating engine lubricants to balance the need for high efficiency with consistent operational durability. SwRI is helping develop new methods to evaluate these characteristics in the new fluids (enginelubes.swri.org).

Driven by these industry needs, as well as other factors, we assist in developing new fuel and lubricant evaluation technologies. In the past several years, our staff has helped develop new tests to support the PC-11 lubricant category targeting on-highway diesel trucks and the GF-6 standards for gasoline passenger cars. We helped develop three tests for the PC-11 categories and five tests for the GF-6 standards. Combined, these new tests have made 2014 the busiest year in SwRI’s history for automotive lubricant test development.

Once industry accepts these and other automotive tests and the test procedures are published, we are then able to offer independent evaluation services.

SwRI modified a 2.3-liter production engine to utilize High-Efficiency Dilute Gasoline Engine (HEDGE®) technologies. To date, the engine is demonstrating class-leading fuel economy that exceeds project targets.

We significantly expanded our diesel engine facilities to support increased demand for testing and continue to refurbish engine cells for the gasoline tests going into effect in 2015.

To support our fuels evaluation work, we also enhanced fuel blending and handling facilities. The new operation increases the accuracy of fuel blends and minimizes fuel transfers, which helps maintain the integrity of both the fuel and the test.
We also evaluate the friction, lubricity, and wear of moving engine parts and ancillaries, which is increasingly important as engines come to rely on lower-viscosity engine oils and alternative fuels to improve fuel economy and performance (tribology.swri.org).

Our staff developed a unique high-pressure, high-frequency reciprocating rig (HP-HFRR) to evaluate fuel lubricity in high-speed, high-temperature, high-contact stress environments, such as those found in fuel pumps. The standard HFRR has open fluid reservoirs, which preclude testing volatile fluids such as propane, natural gas, and dimethyl ether. Our system has a sealed reservoir, allowing us to test volatile and gaseous fluids at higher temperatures and pressures.

SwRI has been recognized by the Chinese Ministry of Environmental Protection as the only engine test facility outside of China eligible to perform its emission certification testing. We also completed the first Chinese certification test with additional agency representatives from the European Union, Canada, India, and the United States, enabling multi-country certifications during a single engine installation and providing a significant cost savings for the manufacturer (emissionsresearch.swri.org).

For the California Air Resources Board, SwRI is leading a three-year effort to demonstrate new emissions technologies and cold-start control strategies that can lower oxides of nitrogen emissions levels from well below the current heavy-duty standard of 0.2 grams per brake horsepower-hour. Staff members will use diesel and compressed natural gas engines to demonstrate the project target of 0.02 g/bhp-hr.

SwRI technicians evaluate automotive fluids and additives for their ability to operate within the demanding performance and endurance environment of a vehicle. These tubes contain elastomer materials, such as the kind used in automotive seals, submerged in oil baths to artificially age the material. We then perform a variety of elastomer compatibility tests, such as the strain test shown at right.

SwRI engineers develop open-source MATLAB® Simulink®-based engine control software to operate gasoline and diesel engines without the manufacturer’s electronic control unit. Our system has been applied to engines ranging from shipboard power plants to a turbocharged gasoline direct-injection engine (annarbor.swri.org).
representing a 90-percent reduction from the current standard. Our FOCAS® HGTR® diesel burner system will be used to provide calibration assistance and assess the optimal performance of the advanced technologies studied under this program.

SwRI has pioneered developing and managing automotive industry consortia (consortia.swri.org). Two of its most successful consortia, Clean High-Efficiency Diesel Engines (CHEDE) and High-Efficiency Dilute Gasoline Engine (HEDGE), have tackled some of the most challenging issues facing diesel and gasoline engine manufacturers. Together, they have developed fuel efficiency and emissions reduction technologies currently in production for today’s passenger cars and heavy-duty trucks.

Other ongoing consortia programs are addressing challenges with energy storage systems (esses.swri.org), particle sensor performance and durability (pspd.swri.org), and low-speed pre-ignition (p3.swri.org). The latter spawned a new program, examining advanced engine fluids to understand how fuels and lubricants affect engine combustion by investigating the fundamental chemistry and physics of low-speed pre-ignition, which causes damaging severe engine knock (aef.swri.org).

We are leading another new consortium with collaborative support from the Oak Ridge National Laboratory. This consortium will examine emissions from advanced combustion engines and further our understanding of conventional and advanced catalyst systems to improve the integration of emission control systems into future powertrain architectures (ac2at.swri.org).

For a Chinese client, SwRI is developing a 2.3-liter engine for production that incorporates HEDGE technology (hedge.swri.org). The new engine has exceeded project
targets by demonstrating class-leading fuel economy. Based on the success of this effort, we are applying the same technology to a 1.8-L version of the engine.

We also developed a new method and control system to improve the precision of chassis dynamometer fuel economy tests beyond the abilities provided by human drivers and mechanical robots. This approach measures fuel economy improvements of less than 0.1 miles per gallon from passenger vehicles that use advanced fuels and lubricants.

The recent success of hydraulic fracturing technology in capturing previously inaccessible natural gas in the United States is sparking renewed interest in using natural gas as a vehicle fuel. With funding from the National Renewable Energy Laboratory, we are applying HEDGE technology to a modern, spark-ignited natural gas engine. The program is demonstrating higher torque and power, better efficiency, and emissions well below levels allowed by law. The engine will be certified to U.S. 2010 standards and installed in articulated buses for evaluation. We are helping several other manufacturers convert their engines to natural gas operation, and we also are helping to obtain certification in the U.S. and elsewhere.

Manufacturers are increasingly interested in converting high-horsepower diesel engines to dual-fuel operation, despite changes in emissions and combustion. We are using internal research funds to investigate dual-fuel knock characteristics and other combustion phenomena using experimental testing and combustion modeling to identify the unique operating limitations of heavy-duty and high-horsepower dual-fuel engines.

Our staff operates the TARDEC Fuels and Lubricants Research Facility at SwRI, a government-owned laboratory dedicated to providing specialized service to the U.S. Army fuels and lubricants technical program (tardec.swri.org). Current research includes the development of an acoustic-adiabatic test apparatus to measure fluid compressibility. Staff members also are investigating and qualifying alternative fuels for use in Army ground vehicles and equipment. We have operated military diesel engines using blends of alternative fuel and JP-8 aviation fuel to determine their impact and compatibility with Army equipment.

SwRI engineers developed a unique high-frequency reciprocating rig to evaluate fuel lubricity of alternative fuels, including volatile and gaseous fuels.

Visit engineandvehicle.swri.org or fuelsandlubricants.swri.org for more information or contact Vice President Bruce Bykowski at (210) 522-2937 or bruce.bykowski@swri.org or Vice President Steven D. Marty, P.E., at (210) 522-5929 or steven.marty@swri.org.
SwRI delivered a large-scale automated paint system to the Red River Army Depot.
The multi-robot system can paint up to 40 ground vehicles a day.

As our lives become increasingly interconnected through technology, embedded systems and smart devices within the existing Internet infrastructure are expected to usher in unprecedented automation and advances. Southwest Research Institute specializes in the system architectures, communications, and security that will be needed to facilitate this new wave of network and automation advances, including next-generation manufacturing systems. We integrate commercial hardware using sophisticated software to deploy the most cost-effective solutions for our clients.

We are in the midst of the VICTORY program, a multiyear, multimillion dollar standardization effort to help the U.S. Army realize a reduction in size, weight, power, and costs associated with ground vehicle electronics. We are defining the architecture to more efficiently integrate new electronics systems into ground vehicles and successfully executed a VICTORY architecture integration demonstration project for night vision and electronic sensor packages. We also are adapting our processes for standard architecture design to help modernize and advance various facets of the sports industry, integrating wearable sensors and data-centric subsystems in a standard way.

As a world leader in connected automation and intelligent transportation systems (ITS), SwRI has developed connected vehicle and automated vehicle capabilities, such as automated vehicle platoons, gesture interaction with automated vehicles, and variable spacing and offsets, as well as precision navigation and localization. SwRI maintains a fleet of automated vehicles, including passenger vehicles, a tractor-trailer, and various military ground vehicles (ivs.swri.org).

Using our ActiveITS software package, we are developing intelligent transportation technology to address the particularly lethal problem of wrong-way
drivers. We continue to be a national leader in advanced state-owned traffic management systems and have more than 40 deployed systems in Florida and Texas. In 2014, we expanded our program through a five-year contract with state transportation authorities in New Hampshire, Vermont, and Maine to develop a regional Advanced Transportation Management System. The system will upgrade the highway information infrastructure in northern New England, providing coordinated real-time traffic, safety, and weather information to motorists (its.swri.org).

In 2014, we gained recognition as a leader in automotive cybersecurity. Today’s vehicles are increasingly dependent on embedded systems, small computer components that operate integrated systems from engine timing to anti-lock brakes. As these systems become more accessible via the Internet, it is crucial to safeguard them from outside threats. We are leading the Automotive Consortium for Embedded Security™ to understand and reduce the risk of automotive hacking (aces.swri.org).

SwRI also is a recognized leader in advanced manufacturing solutions. We delivered a large-scale robotic paint system to the Red River Army Depot in Texarkana, Texas, building on decades of experience in large robot-based technology. This new work cell automates a time-consuming, labor-intensive process and is designed to paint up to 40 military Humvee®s a day. The Army is considering adapting the cell for additional ground vehicles (robotics.swri.org).

We continue to lead the ROS-Industrial consortium in North America, while expanding our international impact by collaborating with an organization leading ROS-I activities in Europe. In 2014, the consortium conducted focused technical projects to improve robot path planning, routing, and machining (rosindustrial.swri.org). Closer to home, we help small and medium manufacturers become more competitive in the global economy through services we offer through the Texas Manufacturing Assistance Center (tmac.swri.org).

Visit autodata.swri.org for more information or contact Vice President Susan Crumrine at (210) 522-2089 or susan.crumrine@swri.org.

In cooperation with the U.S. military, SwRI recently deployed two fully automated tactical vehicles to Afghanistan to assess how this technology could support ground troops in the battlefield.
F or more than two decades, Southwest Research Institute electronics engineers have provided critical upgrades to modernize aging electronic aerospace systems for U.S. military and commercial aircraft. We also work with our clients to develop more efficient maintenance procedures for these aircraft. In addition, to ensure the safe operation of military vehicles and commercial equipment, our software engineers and training specialists provide custom training and computer systems.

The A-10 Thunderbolt has been a mainstay of the U.S. Air Force since its debut in the 1970s. To keep this legacy aircraft a viable force for the U.S. fleet, our engineers are involved in a number of projects designed to upgrade or enhance the aircraft (aircraftsystems.swri.org).

This past June, we delivered the last of 380 Improved Electronic Processor Units (IEPU) designed, produced, and tested for the A-10 fleet. The IEPU-50 enables long-term support of the aircraft’s systems by combining turbine engine monitoring and flight load data recorder functions into a single, line-replaceable unit supported by software tools.

The Up-Front Controller, located in the cockpit of the A-10, is a multi-purpose alphanumeric keypad used to control the Heads-Up Display and Control Display Unit data entry. We
updated 60 controller units to provide new functions now available to the pilot. We also developed a test procedure for both initial and final inspection of the units, and evaluated and repaired several non-functioning units.

Our researchers are working with a commercial client on a National Science Foundation program to modify an A-10C to serve as a weather research plane, the A-10 Storm Penetrating Aircraft (SPA). We are designing a dual independent power system to support instrumentation for collecting weather data as the plane flies through violent storms (avionics.swri.org).

Unmanned Aircraft Systems Center of Excellence and Innovation, one of six test sites designated by the FAA in December 2013 to assist the agency’s regulatory effort to integrate unmanned aircraft into the national airspace system. We will provide our decades of experience in unmanned aircraft systems design and evaluation, along with support for environmental assessments and impact studies (uav.swri.org).

In addition to our aerospace expertise, we design and develop simulators to train construction, forestry, and agricultural equipment operators. These training simulators provide virtual environments in which realistic scenarios facilitate training in proper operator technique, machine controls, and safe operation. Actual machine controls and a three-degrees-of-freedom motion platform are incorporated into the simulators. This year, we delivered more than 100 training simulators throughout the United States and to countries around the world. (simulation.swri.org).

For more information, contact Vice President Nils Smith at (210) 522-3685 or nils.smith@swri.org, Vice President Ken Bennett at (210) 522-5242 or kenneth.bennett@swri.org, or Vice President Susan Crumrine at (210) 522-2089 or susan.crumrine@swri.org.

Our engineers design and build training systems for a variety of equipment, such as this backhoe simulator. These systems include actual machine controls and 3-D virtual simulation software, providing a realistic environment for teaching proper operation of the equipment (simulation.swri.org).
Since 1947, Southwest Research Institute's mechanical engineering program has provided a range of research, development, and evaluation services to both government and industry clients. This core program encompasses materials, structures, fluids and machinery dynamics, nondestructive evaluation, sensor technology, and energetic systems.

We continue to support the needs of the oil and gas industry in shale and deep water production and the associated infrastructure for processing and transporting oil and natural gas. We initiated joint industry programs to address corrosion fatigue, offshore leak detection, and offshore weld inspection technology. We also are leading the Separation Technology Research (STAR) Program, a multimillion-dollar, international, joint industry program that combines industry knowledge and resources to advance research for better separation equipment and test protocols (starprogram.swri.org). Another critical industry need is validating oil field product performance to industry standards. To accomplish this broad-based program, we have invested substantially in new laboratories and facilities that closely simulate real-world operating conditions.

To address factors associated with climate change, we are developing clean energy technology under several U.S. Department of Energy (DOE) contracts. We recently completed a nine-year DOE effort to design, fabricate, and test a 3.5-megawatt high-efficiency centrifugal compressor. This design has the potential to reduce significantly the energy required for carbon separation and sequestration technologies in fossil-fueled power plants. Also for DOE’s SunShot Initiative, we completed the design of two concentrating solar power (CSP) elements for improved compressor efficiency. CSPs typically generate steam to support electric power generation, yielding about 40 percent thermal efficiency. SwRI’s design will combine CSP technologies with more efficient gas-turbine cycle plants for higher efficiencies. Both CSP elements are now in the construction phase (machinery.swri.org).

Our long-running Aircraft Structural Integrity Program supports the military’s need to extend the structural lives of existing air fleets. Under contract to the U.S. Air Force, we are providing modeling and full-scale fatigue testing of both the T-38 and A-10 aircraft. We also are conducting nondestructive inspections and analyzing unconventional repair techniques for

SwRI opened a new environmentally controlled 11,224-square-foot facility for fabricating and testing large, heavy components. The building, which houses 100-ton and 50-ton cranes, complements existing facilities and enhances our services and research capabilities for oil and gas, aerospace, marine, and industrial clients (structural-engr.swri.org). An expansion, expected to be completed in May 2015, will add 8,828 square feet to the facility.
these legacy aircraft, allowing the fleets to fly safely decades past their original design life (aerospacestructures.swri.org).

We recently completed a major project for the Defense Advanced Research Projects Agency to develop models to speed up the design, verification, and fabrication of next-generation infantry fighting vehicles. This multidisciplinary effort involved projectile impact and explosive blast analysis, materials modeling, and software development. The goal was to produce a vehicle that is “correct by construction” and to reduce by a factor of five the time from concept to rolling vehicle. We delivered survivability analysis software tools used extensively by DARPA in design exercises (engineeringdynamics.swri.org).

To support the oil and gas industry, SwRI expanded its Multiphase Flow Facility to conduct high-pressure, three-phase (oil/water/gas) testing under field-like multiphase and wet gas conditions (multiphase.swri.org). The facility also will be used to evaluate technologies developed under a newly formed joint industry endeavor, the Separation Technology Research (STAR) Program.

We also are part of a team selected to establish a manufacturing institute as part of the White House’s National Network for Manufacturing Innovation initiative. The initiative’s goal is to re-establish the United States as a leader in manufacturing. The new institute, the American Lightweight Materials Manufacturing Innovation Institute (ALMMII), will be established in Detroit. SwRI will serve as a technology leader focused on validation and certification, ensuring all model development includes a plan to validate and quantify confidence in the model, and staff members also will participate in ALMMII-funded research projects (mateng.swri.org).

Visit mechanicalengineering.swri.org for more information or contact Vice President Danny Deffenbaugh at (210) 522-2384 or danny.deffenbaugh@swri.org.

SwRI researchers are developing magnetostrictive transducer sensor technology for inspecting nuclear power plant components, such as containment vessels, as modeled in the mockup shown. The sensor generates a guided wave that travels many meters along thick steel walls. We have developed similar nondestructive evaluation systems for a wide range of applications from pipelines to bridges (ndesensors.swri.org).
Southwest Research Institute is home to one of the nation’s leading space science and engineering programs, emphasizing both basic research and the development of innovative instrumentation, electronics, and avionics systems. With its role in NASA’s Cyclone Global Navigation Satellite System (CYGNSS) mission, SwRI has expanded the scope of its activities to include developing microsatellites for space-based Earth observation.

SwRI-developed instruments are flying on a number of NASA and European Space Agency (ESA) spacecraft. Two SwRI-built instruments, the Ion and Electron Sensor and an ultraviolet (UV) imaging spectrometer, are part of the science payload of ESA’s Rosetta spacecraft, which rendezvoused with comet 67P/Churyumov-Gerasimenko this summer. Rosetta will observe the comet as it travels from its present location outside the orbit of Mars toward and around the Sun.

Our UV spectrometers and plasma instruments also are on board the Juno spacecraft, now some 420 million miles from Earth on its way to Jupiter, and the New Horizons probe, headed for its encounter with Pluto in July 2015. Another UV spectrometer, under development for an ESA mission to explore Jupiter and its icy moons, recently completed ESA and NASA system requirements reviews.

Other SwRI-built instruments are being readied for flight on ESA’s BepiColombo Mercury orbiter and the Solar Orbiter, launching in 2016 and 2017, respectively. We also are building a novel miniaturized ion sensor to measure solar energetic particle precipitation into Earth’s high-latitude atmosphere; the detector will fly on a CubeSat, a miniaturized satellite platform used for research, exploration, and technology development.

In addition to its instrumentation role, SwRI is the principal investigator institution for the Juno, New Horizons, and Interstellar Boundary Explorer missions. We also lead the science investigation for NASA’s four-spacecraft Magnetospheric Multiscale (MMS) mission and are responsible for developing the instrument suite, which includes SwRI’s Hot Plasma Composition Analyzer. The four spacecraft recently shipped to Cape Canaveral, where they are undergoing functional testing before launch in March 2015.

Our research program covers a variety of topics in space and planetary science, including terrestrial and planetary magnetospheres, the icy moons of Saturn and Jupiter, the solar wind and its interaction with the interstellar medium, the hydrology and radiation environment of Mars, and solar and planetary system formation.

Noteworthy scientific accomplishments this year include discovering a transient 200-kilometer-high plume of water erupting from the south pole of Jupiter’s icy moon Europa and developing a new computer model...
to better understand how asteroids bombarded the Earth between 4 and 4.5 billion years ago. The model shows these myriad impacts would have “reprocessed” the Earth’s surface, melting landmasses and vaporizing existing oceans.

SwRI continues to provide innovative solutions for advanced spacecraft avionics and payload processing systems, including Ethernet-based distributed flight control computers and advanced solid-state recorders that achieve a tenfold increase in data storage capacity and throughput over traditional systems. Advanced solid-state recorders currently are being developed for two Department of Defense (DOD) projects and the joint NASA-Indian Space Research Organization Synthetic Aperture Radar satellite. Based on our experience with CYGNSS, we also are building avionics systems for two DOD small satellites.

Visit spacescience.swri.org for more information or contact Vice President Dr. James L. Burch at (210) 522-2526 or jim.burch@swri.org.

As part of an international team, SwRI scientists are investigating the origin, physical properties and composition of comet 67P/Churyumov-Gerasimenko. Among the questions researchers hope the Rosetta mission will answer is the role that comets may have played in delivering water to the primordial Earth.
For more than 25 years, Southwest Research Institute has operated a Center of Excellence in Earth Sciences and Engineering®, with a focus on energy, water resources, and planetary geology. We continue operating the Center for Nuclear Waste Regulatory Analyses to support the Nuclear Regulatory Commission (NRC) in fulfilling its regulatory responsibilities related to radioactive waste storage, transportation, and disposal (cnwraweb.swri.org). In addition, the Center assisted NRC with technical issues related to uranium production, fabrication of nuclear fuel, power reactor licensing, and storing spent fuel in pools and dry casks, as well as related environmental studies.

We conducted natural hazard assessments of critical infrastructure, such as nuclear fuel cycle facilities, and conducted seismic hazard assessment reviews for three nuclear power plants in the western United States. In addition, we supported NRC regulatory reviews associated with seismic and flood hazards for selected nuclear power plants nationwide.

We continue to export our repository expertise, reviewing license applications for radioactive waste disposal sites in Finland and Sweden and supporting repository investigations in France.

SwRI’s petroleum exploration and development program has grown substantially, doubling revenue from licensing our award-winning 3DStress® software and expanding our structural geology and geomechanical training course offerings for the oil and gas industry. Although work on conventional sandstone and carbonate reservoirs continues to be a major focus of our project work, research focused on several unconventional reservoirs in the U.S. and Canada has rapidly expanded. Using internal research funding, we are making advances in modeling hydraulic fracturing processes, as well as analyzing how wastewater injected into deep aquifers can trigger seismic events like earthquakes. To facilitate these analyses, SwRI geologists are adding a new capability to address fluid injection and resulting pore pressure changes into an upcoming release of our 3DStress software (3dstress.swri.org).
In 2014, we completed Phase I of the Eagle Ford structural geology joint industry project and launched Phase II with a continued focus on mechanical stratigraphy, natural fracturing, stress fields, fluid history, and induced hydraulic fracturing. These areas are all critical to successful production from the Eagle Ford Formation reservoir in South Texas, as well as other unconventional reservoirs.

As global and local concerns grow about groundwater availability, quality, and contamination, we continue expanding capabilities and applications to meet the needs of government agencies and municipal and commercial organizations. Using internal research funding, we have developed expertise in understanding how water resources may be affected by hydraulic fracturing. Leveraging these results, we are now conducting project work related to oil and gas development.

Our hydrologists continued a major three-year project with the Edwards Aquifer Authority, modeling groundwater availability to better understand natural processes. We also assisted an increased number of underground water conservation districts throughout South Central Texas, modeling relevant groundwater systems, taking into consideration geological structure and geochemistry (hydrology.swri.org).

For NASA, we apply expertise in earth science to other planetary bodies, studying dikes, landslides, and other geological features on Mars (analogmodel.swri.org). We also are simulating satellite imagery to be acquired by the Hyperspectral Infrared Imager (HyspIRI) mission, which will observe Earth's changing ecosystems and natural disasters (planetarygeosciences.swri.org). We are continuing to develop and apply capabilities for monitoring vertical and horizontal ground movements using Interferometric Synthetic Aperture Radar methods through externally funded projects and internal research and development funding.

Visit geosciences-engineering.swri.org for more information or contact Vice President Dr. Wesley Patrick at (210) 522-5158 or wesley.patrick@swri.org.

Using methods developed with internal research funds, SwRI scientists collaborated with the Japan Atomic Energy Agency to detect radioactive hotspots on the ground near the Fukushima Daiichi Nuclear Power Station using a drone flying at 50–70 meters.
As the volume and nature of communication signals proliferate and evolve, Southwest Research Institute is focusing efforts on supporting the United States and foreign governments with innovative communications signal intercept, direction-finding, surveillance, geolocation, and tracking technologies.

“Multi-intelligence,” the fusion of multiple types of data, provides a big-picture snapshot of information for military and surveillance operations. Applying our expertise in signals intelligence as well as artificial intelligence, we are developing automated systems to collect, process, and analyze enormous volumes of real-time data from multiple sources to report relevant actionable information based on sensor, data, and user-contextual needs. These systems provide tactical, operational, and strategic information in real time and near real time (ad.swri.org).

Our staff has been actively involved in all aspects of angle-of-arrival geolocation networks. We have delivered the initial operational capability for a high-performance worldwide geolocation network. That system includes modern messaging technology, innovative mission management, high-performance data storage, retrieval, display, advanced geolocation algorithms, and new network management and monitoring capabilities. In conjunction with this effort, we are establishing angle-of-arrival capability between dissimilar systems to provide geolocation network interoperability.
This work is being accomplished through the use of the Theater Netcentric Geolocation (TNG) infrastructure. As a member of TNG working groups, SwRI is a leader in the advancement of angle-of-arrival operations in tactical geolocation network operations.

Our researchers also are optimizing the process of searching for and analyzing new communication signals, which must frequently be performed manually. We are investigating “locate-to-collect” concepts to determine every signal’s geographic origin first and then highlight only those signals emanating from a geographic region of interest for further scrutiny and analysis.

To address emerging maritime communications requirements, we are developing a new VHF/UHF architecture that integrates multiple-channel wideband digital receivers, enhanced network data flow, enhanced VHF/UHF signal characterization, and tactical operator displays.

The Naval Air Systems Command awarded SwRI a program to develop VHF/UHF SIGINT direction finding technology. The program includes developing field-programmable gate array (FPGA) processing and airborne geolocation algorithms.

We are developing a prototype robot system to inspect overhead power lines and demonstrated its ability to operate in demanding environments, such as heavy rain and freezing cold. Future efforts include using the robot on an operating power transmission line.

We recently applied our expertise in complex radio frequency and image and digital communication signal processing to space flight systems requiring high reliability.

SwRI uses internal research funds to help develop new technologies and pave the way for client-sponsored programs. For one project, we integrated a VHF/UHF frequency band operator-driven signal survey capability that covers up to 320 megahertz of bandwidth instantaneously.

Signal processing functions are software defined and hosted on commodity multi-core servers (sigalexploration.swri.org).

We also funded the development of a VHF/UHF direction finding system in a compact pod that can be installed in multiple helicopter platforms. In addition, we developed FPGA-based demodulators and decoders to reduce size, weight, and power applications for unmanned aerial systems.

Visit sigint.swri.org for more information or contact Vice President Nils Smith at (210) 522-3685 or nils.smith@swri.org.

SwRI recently designed, integrated, and delivered an HF/VHF/UHF compact portable wideband survey and collection system called Scout™.
or battery power for propulsion, and could be adapted as a power source for other applications.

This year, SwRI again supported the Defense Advanced Research Projects Agency (DARPA) Robotics Challenge, setting up disaster response trials for humanoid robots. Teams compete in challenges designed to evaluate how well these robots could help humans respond to natural and man-made disasters. Our engineers operated a task requiring robot

Engineers fabricated thermally actuated polymer artificial muscles (TPAMS) and are evaluating using TPAMS to operate the rudder of a small unmanned aerial system.

With a diverse staff and world-class expertise, Southwest Research Institute pushes the boundaries of engineering and physics to create advanced technologies and systems to meet clients’ challenging demands. We also evaluate novel robot systems and develop algorithms to expand the range and application of materials and systems. Our staff takes new approaches to address persistent problems cost effectively.

SwRI engineers are addressing the weight of war, looking to lighten the loads combat soldiers must carry into battle. Batteries make up 20 percent of the weight of that load and rank second behind munitions in annual infantry battalion expenditures, according to a recent U.S. Army study. This year, SwRI completed the first design phase for a rugged, lightweight solar module to recharge batteries in the field. To maximize the efficiency of the energy harvesting system, engineers are studying the structures of moth eyes to develop light-absorbing coatings for photovoltaic cells and techniques to create these cells.

A multidisciplinary team has developed, built, tested, and delivered a novel hybrid power system for an unmanned aerial system (UAS) suited for stealthy surveillance missions. The system combines the speed and range of gas-powered flight with the low noise levels of electric power, allowing the aircraft to reach distant targets quickly and efficiently, while operating quietly at the mission site. The patented gas turbine drives an electric generator, allowing the UAS to operate using gas

- 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
- non-lethal weapons
- MEMS
- robotic vehicle evaluations
- failure analysis
- rapid prototyping
- miniaturization technologies
- geophysics
competitors to drive an all-terrain vehicle and built a belay system designed to protect robots from damage as they attempted to move up and down a simulated ship’s ladder.

Artificial muscle technologies have many potential applications in machines, including robots and industrial actuators. Using internal research funding, researchers fabricated and evaluated a series of thermally actuated polymer artificial muscles (TPAMs), using twisted polymer monofilaments and yarns. These TPAMs have similar performance to shape memory alloy devices, but are an order of magnitude less expensive, have a higher strength-to-weight ratio, and have a greater actuation range. SwRI is investigating using this technology to control the rudder of a small unmanned aerial system.

Engineers also are developing a software algorithm to adjust the force needed to activate a pushbutton device. Run on a tiny microprocessor connected to a pressure sensor, the algorithm intelligently senses pressures over time and dynamically adapts to a person with diminishing strength or capacity, such as someone with amyotrophic lateral sclerosis, a progressive neurodegenerative disease. Such a device could allow continued use of a pushbutton adaptive system, such as a voice-generating tablet computer.

In 2014, our microbiology laboratory was accredited to perform good laboratory practice testing to Environmental Protection Agency and U.S. Food and Drug Administration standards. SwRI helps clients evaluate disinfectants and sterilants to EPA performance guidelines. Visit applied-physics.swri.org for more information or contact Vice President Ken Bennett at (210) 522-5242 or kenneth.bennett@swri.org.
At Southwest Research Institute, we develop advanced chemistry and chemical engineering solutions to help our clients address challenges ranging from alternative energy to human health and safety. We develop novel pharmaceutical formulations and product additives using unique capabilities in micro- and nanoencapsulation technology. Working with industry and government, our scientists also develop new hydrocarbon processing technologies; support environmental studies; and verify the safety of food, consumer products, and construction materials. We also apply technology to support homeland security efforts.

SwRI chemical engineers are advancing production of cleaner renewable energy sources by building and operating pilot plants for new proprietary processes. SwRI helped launch first-of-its-kind carbon capture and sequestration technology at a commercial plant in San Antonio (chemeng.swri.org).

In 2014, SwRI put a novel circulating fluidized bed reactor online to convert heavy crude oils or biological feedstocks, such as corn fiber, into valuable refined fuel samples. Producing samples at about a half liter per hour, the facility supports new biofuel catalyst evaluations and allows researchers to ascertain how plant-derived biofeedstocks and bio-oils can be efficiently integrated into refineries (biofuelprocessdev.swri.org).

For offshore gas pipeline applications, SwRI developed a technique to quantify how gas processing solvents behave under the high pressures and variable temperatures representative of subsea environments. We developed a laboratory test setup to monitor and characterize low levels of solvents in real time for dense phases of natural gas and near-supercritical states of carbon dioxide.

SwRI provides integrated pharmaceutical services to clients in biotech, government, and academia, including drug discovery based on modeling and medicinal chemistry as well as...
complete characterization of products. We also can scale-up formulation and production of clinical supplies for animal studies and clinical trials under facilities meeting current good manufacturing practices guidelines (pharmdev.swri.org).

SwRI has more than 60 years of experience in micro-encapsulation technology. We are developing specialized nozzles to extrude discrete coated fibers for long-term controlled release to treat chronic disease or to control parasites in veterinary applications. We are developing implants to treat thyroid disorders, cardiovascular disease, malaria, and cattle fever (drugdelivery.swri.org).

Working with the Department of Defense, our biomedical scientists are developing collagen-based biomasks to help regenerate facial tissue after traumatic injuries. To create a biomask, a collagen matrix is electrochemically deposited onto a gold-coated facial profile, generated using 3-D printing (matbioeng.swri.org).

Polymeric materials or plastics are ubiquitous in our everyday life, but these materials can be far more flammable than natural materials and require treatment with fire retardants to meet safety standards. Concerns about the safety of brominated fire retardants are generating extensive research to develop and test more environmentally friendly fire retardants. SwRI works with manufacturers to help develop new fire retardants and evaluate products entering the market (fire.swri.org).

SwRI chemists also develop novel, quick-turnaround, cost-effective techniques to assess chemical and radiological residues in food, soil, and water and to identify the unique biomarkers of exposure and characterize risks to human health and safety (environmentalchemistry.swri.org).

Visit chemistry.swri.org for more information or contact Vice President Dr. Michael MacNaughton at (210) 522-5162 or michael.macnaughton@swri.org.
**Consolidated Financial Statements**

For the years ended September 26, 2014, and September 27, 2013

### Income Statements (in thousands of dollars)

<table>
<thead>
<tr>
<th></th>
<th>2014</th>
<th>2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revenue</td>
<td>$548,783</td>
<td>$591,730</td>
</tr>
<tr>
<td>Direct Project Costs</td>
<td>331,037</td>
<td>346,181</td>
</tr>
<tr>
<td>Operating Income</td>
<td>217,746</td>
<td>245,549</td>
</tr>
<tr>
<td>Division Operating Expenses</td>
<td>139,184</td>
<td>133,871</td>
</tr>
<tr>
<td>General Overhead</td>
<td>53,407</td>
<td>59,489</td>
</tr>
<tr>
<td>Depreciation — General Facilities</td>
<td>15,945</td>
<td>15,666</td>
</tr>
<tr>
<td>Internal Research</td>
<td>6,861</td>
<td>6,769</td>
</tr>
<tr>
<td>Realized/Unrealized Gain on Postretirement Medical Funds</td>
<td>(4,213)</td>
<td>(5,793)</td>
</tr>
<tr>
<td>Income Before Federal Income Tax Expense</td>
<td>6,562</td>
<td>35,547</td>
</tr>
<tr>
<td>Federal Income Tax Credit</td>
<td>(1,335)</td>
<td>(97)</td>
</tr>
<tr>
<td><strong>Net Income</strong></td>
<td><strong>$7,897</strong></td>
<td><strong>$35,644</strong></td>
</tr>
</tbody>
</table>

### Balance Sheets (in thousands of dollars)

<table>
<thead>
<tr>
<th></th>
<th>2014</th>
<th>2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current Assets</td>
<td>$246,751</td>
<td>$233,338</td>
</tr>
<tr>
<td>Property and Equipment, Net</td>
<td>292,540</td>
<td>288,017</td>
</tr>
<tr>
<td>Other Assets</td>
<td>114,038</td>
<td>127,056</td>
</tr>
<tr>
<td><strong>Total Assets</strong></td>
<td><strong>$653,329</strong></td>
<td><strong>$648,411</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>2014</th>
<th>2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current Liabilities</td>
<td>$104,634</td>
<td>$97,823</td>
</tr>
<tr>
<td>Noncurrent Liabilities</td>
<td>60,982</td>
<td>67,077</td>
</tr>
<tr>
<td>Net Assets</td>
<td>487,713</td>
<td>483,511</td>
</tr>
<tr>
<td><strong>Total Liabilities and Net Assets</strong></td>
<td><strong>$653,329</strong></td>
<td><strong>$648,411</strong></td>
</tr>
</tbody>
</table>

**Total Assets**

(Millions $)

**Net Assets**

(Millions $)
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