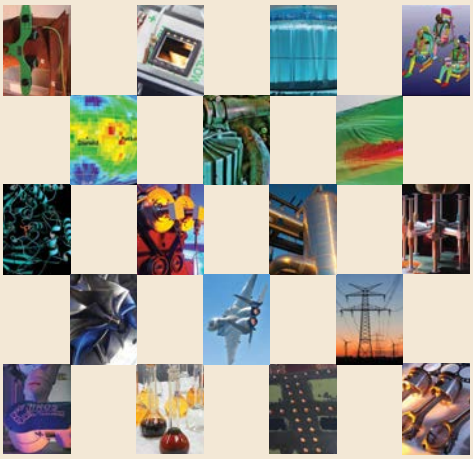
Southwest Research Institute®

Annual Report 2013

Southwest Research Institute

Benefiting government, industry and the public through innovative science and technology



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.

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Message from the President

Multidivisional collaboration to solve problems for government and industry clients has been a hallmark of Southwest Research Institute for more than 65 years. This past year was no exception. Our interdivisional approach helped the Institute reach record revenues, drawn from thousands of ongoing technical programs. We have a truly diverse project portfolio, and this annual report highlights just some of the notable accomplishments our staff achieved in 2013.

Our collaborative philosophy is reflected in client work on myriad projects attacking complex problems from many different viewpoints. For example, the Energy Storage Technology Center combines expertise in energy storage with battery research and technology development capabilities. Our longstanding involvement with the A-10 Thunderbolt program keeps one of the country's most effective warfighting aircraft on the cutting edge and on the front line. The Smart Power Infrastructure Demonstration for Energy Reliability and Security Program enables electric vehicles not only to be recharged, but to transfer power back onto the grid when needed.

Together with our government and industry clients, we share a common vision to advance technology and science. To that end, the Institute opened the Earth, Oceans and Space Department at the University of New Hampshire to collaborate on proposals for NASA, the National Oceanic and Atmospheric Association and the National Science Foundation. We continued collaboration with the U.S. Army, Department of Defense and multi-institutional centers with joint proposals in wound healing, bioengineered scaffolds and tissue engineering, molecule synthesis and medical countermeasures. And we joined the Armed Forces Institute of Restorative and Regenerative Medicine to advance treatment of burns and traumatic injuries.

Our management of industry cooperative research programs continues to grow. We launched the third HEDGE® consortium and, along with associated internal research and development efforts, Institute engineers designed the Dedicated Exhaust Gas Recirculation (D-EGR™) concept engine for improved fuel efficiency. The Eagle Ford Joint Industry Project is continuing to improve understanding of fundamental geologic formation relationships and address complex issues associated with oil shale production and related environmental concerns. The ROS-Industrial Consortium was launched to advance factory automation, and the Automotive Consortium for Embedded Security™ was initiated to safeguard vehicle control software from outside threats.

Globally, the Institute is working to introduce new engine and aftertreatment technologies in China to help manufacturers meet more stringent emission standards there. High-level nuclear waste repository site development reviews and licensing activities continue in Asia, Europe and Canada. Renewed opportunities have surfaced in unmanned vehicle technologies and in combining unmanned ground and air systems into larger cooperative systems.

Together with our government and industry clients, we share a common vision to advance technology and science.

Also notable is our internal research and development program, which provides our staff opportunities to explore innovative concepts and bolsters our science and technology base. Through this program we managed more than 80 projects with expenditures of more than $6.7 million. Many of these are described throughout this report.

Infrastructure projects to better support clients and staff included acquiring the Impact Dynamics Laboratory; completing a new office building for the Chemistry and Chemical Engineering Division; constructing new test cells for the Fuels and Lubricants Research Division; and expanding the Multiphase Flow Facility for the Mechanical Engineering Division.

While facing a number of challenges this past year, including a period of federal budget sequestration, the Institute has worked diligently to expand our technical strengths and resources to meet strategic and fiscal goals. Our technical program in 2013 generated revenues of $592 million, compared to last year's $584 million, with net income of about $36 million. Total payroll was $238 million. A strong backlog of contracts and proposals is an encouraging sign for a successful 2014.

With the support and commitment of our staff, Advisory Trustees and Board of Directors, we see renewed opportunities to further our science and technology base, ensuring our clients continue to receive quality technical services and research in 2014 and beyond.

Respectfully submitted,

J. Dan Bates, President

Highlights

Southwest Research Institute engineers recently built a demonstration vehicle equipped with a production-intent **Dedicated-EGR™** engine expected to improve the vehicle's fuel consumption by an average of **15 percent**. Research developed by our **industry consortia**, specifically the High-Efficiency Dilute Gasoline Engine consortium, led to this remarkable increase in **fuel efficiency**. Member companies receive royalty-free licenses to use consortia-funded technologies.

We recently demonstrated a **vehicle-to-grid aggregation system**, a new method for managing energy, at Fort Carson Army Post, Colo. The system manages a fleet of electric vehicles and controls vehicle charging and microgrid needs, supporting vehicle schedules and supplementing the post's energy supply.

SwRI avionics support has ventured into manned space applications for the first time. We are providing **flight control computers and an actuator control unit** for the Dream Chaser® manned space vehicle — one of three next-generation commercial transport vehicles being developed to replace the space shuttle.

We also are supporting a number of **green energy** projects for the Department of Energy to improve efficiency and advance solar power, supercritical carbon dioxide, clean coal and carbon sequestration technologies.

Staff members founded the Alamo Professional Chapter of **Engineers Without Borders**. EWB aims to support projects "that address basic human needs by contributing expertise in the fields of engineering, project management and the physical sciences."

SwRI and several of its researchers received **national recognition** for professional accomplishments. The Intelligent Transportation Society of New York recognized our participation in the Commercial Vehicle Infrastructure Integration Project as its **Project of the Year**. This was the first significant national effort to integrate **connected vehicle technology** into commercial fleets.

Recognizing its more than 40 years of significant contributions in corrosion research, SwRI received the **International Distinguished Organization Award** from NACE, the leading professional organization for the **corrosion control** industry.

For the third time, SwRI received the Department of Defense **James S. Cogswell Outstanding Industrial Security Achievement Award** for outstanding industry participation in the National Industrial Security Program. SwRI previously received the award in 1992 and 1998.

Dr. Terry Alger was elected a Fellow of the Society of Automotive Engineers, and Dr. Robert L. Mason received the Shewhart Medal from the American Society for Quality for his quality control work for the automotive and petroleum industries.

The **SwRI staff** numbered 2,845 employees. Of those, 280 hold doctorates, 507 hold master's degrees and 703 hold bachelor's degrees. The Institute received 44 U.S. patent awards, filed 51 patent applications and submitted 61 invention disclosures. The technical staff published 555 papers and gave 489 presentations.

Internal Research and Development

Our internal research and development program allows staff engineers and scientists the freedom to explore innovative and unproven concepts. We consider the program, which bridges new ideas with advanced technologies, to be an investment in the solutions our clients will need in the future.

In 2013, SwRI initiated 81 new projects and spent more than $6.7 million on internal research. Some of this year's projects include:

Our internal research program funded the development of the Tactical Aerobotic Launch System, which rapidly inflates, stabilizes, protects and releases lighter-than-air systems from a self-contained package.

novel emulsion-based encapsulation process • erosion prediction capabilities for oil and gas industry applications • development of type II supernova models • inter-satellite transceiver for small spacecraft • D-EGR™ engine and vehicle demonstration • ROS-Industrial strategic technology development • MsSR® 4040SF magnetostrictive sensor technology-electronics hardware • dynamic real-time lane modeling • pre-flight demonstration of a solid-state motion compensation camera • wideband wireless capability on small tactical platforms • practical metamaterial phase shifter • crack-size effect in corrosion-fatigue crack growth • applied central nervous system formulations for treatment of chemical warfare threats and traumatic brain injury • diesel and natural gas dual-fuel engine operating envelope • chemical-based tertiary oil recovery from carbonate rocks • alternative advanced electronic countermeasure techniques • near-Earth object survey simulator • novel formulations of cholesterol-lowering drug to treat ischemia reperfusion injury • control of laser coating removal process • computer vision software for solar transient events • robotic handling of unstructured materials • geophysical detection of subsurface ice • EDAS®-MS upgrade and demonstration preparation • integrated physical analog and numerical modeling of geologic structures • drug-loaded magnetic calcium phosphate nanoparticles for cancer therapy • nanogenerators for energy harvesting • hypothesis testing for subfreezing mass movements • auroral plasma ion spectrometer

ird.swri.org

Automotive Engineering

- gasoline & diesel engine lubricant evaluations
- driveline fluids evaluations
- filtration evaluations
- fuels performance & qualifications
- analytical support services
- fuel economy evaluations
- test stand design & fabrication
- fuel & lubricant surveys, sampling & analyses
- screener development
- computational fluid dynamics
- fire-resistant fuels
- technology support to developing countries
- model-based controls
- engine design
- emissions reduction
- transmission design
- natural gas engine development
- materials compatibility

With automakers facing demanding fuel economy and emissions goals, Southwest Research Institute is strengthening complementary automotive hardware and fuels and lubricants programs by developing innovative technologies to meet client needs.

Continuing its long tradition of service to the fuels and lubricants industries, SwRI is helping to shape the future of gasoline and diesel engine lubricants (engine lubes.swri.org). Spurred by government mandates to increase fuel economy and reduce greenhouse gas emissions, we augmented facilities and equipment to accommodate upcoming PC-11 diesel lubricant requirements.

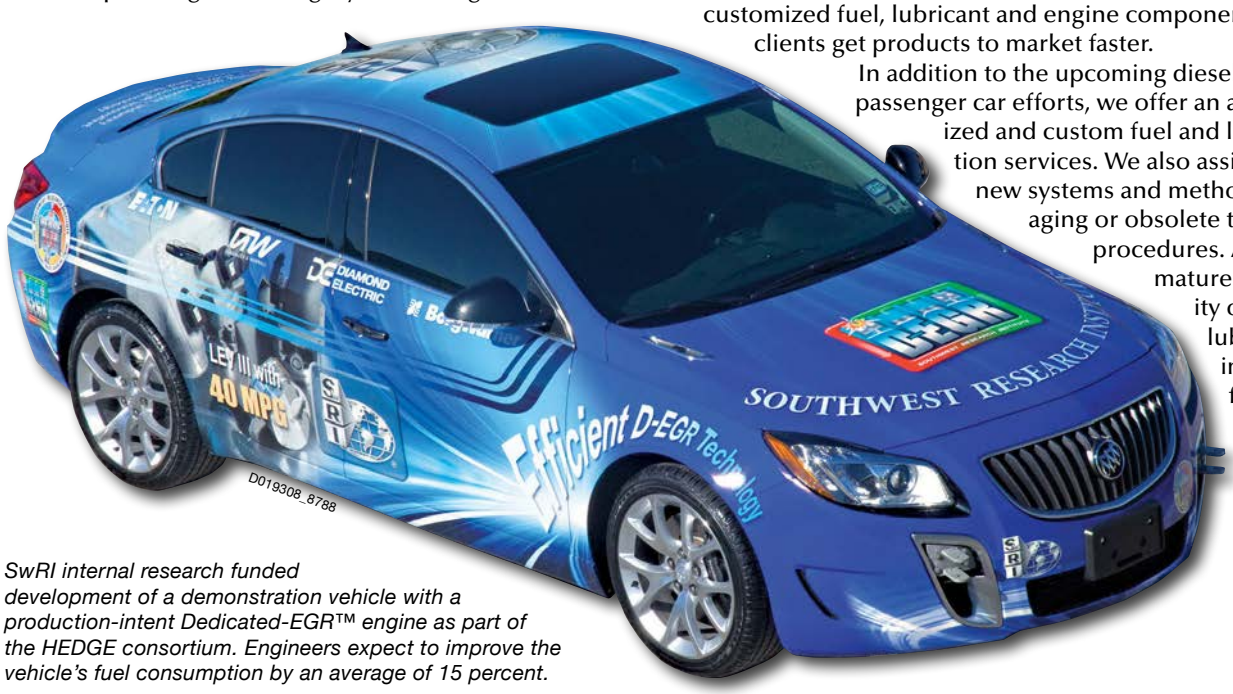
Targeting on-highway diesel trucks, the PC-11 category poses a significant challenge to manufacturers as they strive to maintain current levels of engine durability using new lower-viscosity oils. In addition to helping develop the new tests, we added eight new engine test cells to help manufacturers and suppliers meet competitive and regulatory goals.

Similarly, gasoline passenger cars are being targeted with the upcoming GF-6 category. The new generation of low-viscosity gasoline lubricants addresses the specific needs of new and emerging engine architectures. Our broad spectrum of gasoline and diesel lubricant evaluation services — as well as customized fuel, lubricant and engine component testing — helps clients get products to market faster.

In addition to the upcoming diesel truck and passenger car efforts, we offer an array of standardized and custom fuel and lubricant evaluation services. We also assist in developing new systems and methods to replace aging or obsolete test hardware and procedures. As the industry matures and the quality of fuels and lubricants greatly improves, manufacturers are increasingly seeking to optimize or differentiate

D019199_1844

Our Rapid Prototyping Electronic Control System benchmarks every engine parameter, then allows researchers to evaluate complex control and diagnostic algorithms needed to test and modify engines under development. The system's BOT™ modules solve the unique communication, signal processing, data acquisition and control challenges of powertrain development (rpecs.swri.org).



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SwRI internal research funded development of a demonstration vehicle with a production-intent Dedicated-EGR™ engine as part of the HEDGE consortium. Engineers expect to improve the vehicle's fuel consumption by an average of 15 percent.

We recently completed construction of eight new test cells, expanding our heavy-duty diesel engine lubricant laboratory for the new heavy-duty diesel engine oil category, PC-11. SwRI-developed computer-based data acquisition and control software, called Prism® (inset), complements engine testing.

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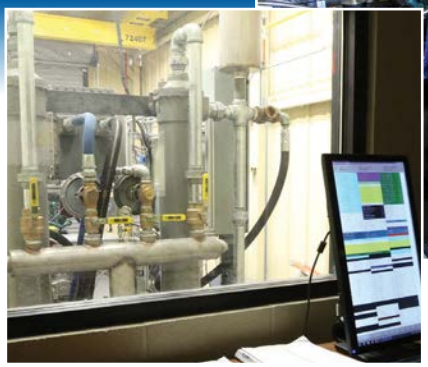

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their products from others on the market. Consequently, up to 40 percent of our work requires non-standard evaluations, a marked contrast to previous years.

The trend toward using lower-viscosity engine oils to improve fuel economy and performance in gasoline and diesel engines requires a thorough examination of the friction, lubrication and wear of moving engine parts. Our comprehensive tribology services include metrology, lubricant characterization, surface and materials analyses, as well as related lubricant research and development services (tribology.swri.org).

SwRI consortia programs allow members to pool funds to address common industry goals, gaining access to more research than can typically be funded by a single organization. Our Clean High-Efficiency Diesel Engine VI consortium builds on nearly 25 years of success, serving as the longest-running research consortium in the world (chede.swri.org). CHEDE develops new technologies to help heavy-duty engine manufacturers meet upcoming carbon dioxide regulations, which require a 6 percent reduction in fuel consumption by 2017. Over the past year, the program demonstrated an industry-leading 48 percent brake thermal efficiency without waste heat recovery.

The High-Efficiency Dilute Gasoline Engine III consortium, now with 27 members, continues to explore engine efficiency-improving technologies. The HEDGE® consortium has developed several promising new technologies, including the DCO™ ignition system, which won an R&D 100 award in 2011 and is undergoing production development at multiple companies; improved understanding of cooled exhaust gas recirculation for higher efficiency in spark-ignited engines; and the Dedicated-EGR™ concept for improved fuel efficiency (hedge.swri.org). Recent developments in the energy market have led to the expansion of the HEDGE work to alternative fuels, such as compressed natural gas and liquefied petroleum gas.

Using SwRI internal research funds, we are developing a demonstration vehicle using a production-intent Dedicated-EGR engine system. Engineers expect an average of 15 percent improvement in the vehicle's fuel consumption.

Another SwRI-managed consortium, the Pre-ignition Prevention Program, is investigating the impact of fuels and lubricants on low speed pre-ignition, a condition causing engine knock that can damage engine parts or cause engine failure (pppconsortium.swri.org). This year, the consortium successfully developed a novel method for analyzing the fluids found in the engine cylinder that cause pre-ignition and is demonstrating significant chemical interactions between the fuel and oil.

Complementing SwRI's fuel, lubricant, emission and engine expertise, SwRI leads the Energy Storage System Evaluation and Safety consortium, which benchmarks and researches commercially available cells for automotive, grid storage

D018954_4910

Torque transducers placed on the camshafts of this gasoline single-cylinder research engine measure the instantaneous friction for comparing lubricants, additives and coatings. SwRI offers a broad spectrum of capabilities for comprehensive tribology studies.

Automotive Engineering cont'd

- alternative fuel evaluations
- powertrain modeling & controls development
- high-efficiency gasoline engine research
- particle science
- engine development
- generator set & combined heat & power evaluations
- homogeneous charge compression ignition
- hydraulic design
- hardware-in-the-loop evaluations
- light-duty fuel economy
- hybrid vehicle design
- contamination research
- wear evaluations
- vehicle testing
- accelerated durability evaluations
- energy storage technologies
- battery evaluations
- applied electronic controls
- tribology

D018424_1078

TFLRF recently completed SAE J1321 fuel consumption improvement testing using three M1083 Family of Medium Tactical Vehicles. Replacing the engine, transmission and axle lubricant improved total fuel consumption by 7 percent over normal baseline MIL-SPEC products.

and other stationary battery markets as a means to advance application development of energy storage systems (esses.swri.org).

Multiple SwRI clients have increased interest in dual-fuel, such as natural gas and diesel, engine technology. SwRI developed and tested controls for a dual-fuel, high-horsepower application that is moving toward production.

Our engineers also are designing a clean sheet, state-of-the-art 2.9 L, 130 kW diesel engine to meet Euro 5 emissions regulations (enginedesign.swri.org). The engine will be used in light- and medium-duty commercial vehicles in developing markets striving to reduce oxides of nitrogen and particulate matter emissions to improve air quality. Production is expected to begin in late 2014.

We also are developing a 2.3 L production HEDGE engine, which involves redesigning the existing engine, as well as vehicle integration and packaging. The new engine is being developed to meet stringent performance, emissions, mechanical reliability, and noise, vibration and harshness targets. Working closely with our client to be one of the first OEMs to offer HEDGE technology to the market, this program will yield world-class fuel economy in luxury sport-class passenger car and SUV platforms.

As heavy-duty engine and truck manufacturers seek any fuel efficiency gains possible to meet new fuel economy and greenhouse gas regulations, they have turned their attention to the reduction of mechanical engine friction, which has not been thoroughly explored in this market. Our engineers recently started a program to measure friction contribution of engine subsystems — such as crankshaft, valve train and piston ring pack — using motoring friction tear-down tests. A high-fidelity motor drives the engine, and changes in torque are measured as different components and systems are removed.

D018854_7854

Our petroleum products research services extend to the extraction of engine emissions and vehicle tire samples for trace measurements of toxic environmental pollutants. Building on this capability, we are funding the development of a method to determine the concentration of polycyclic aromatic hydrocarbons (PAH), an atmospheric pollutant, in tire rubbers.

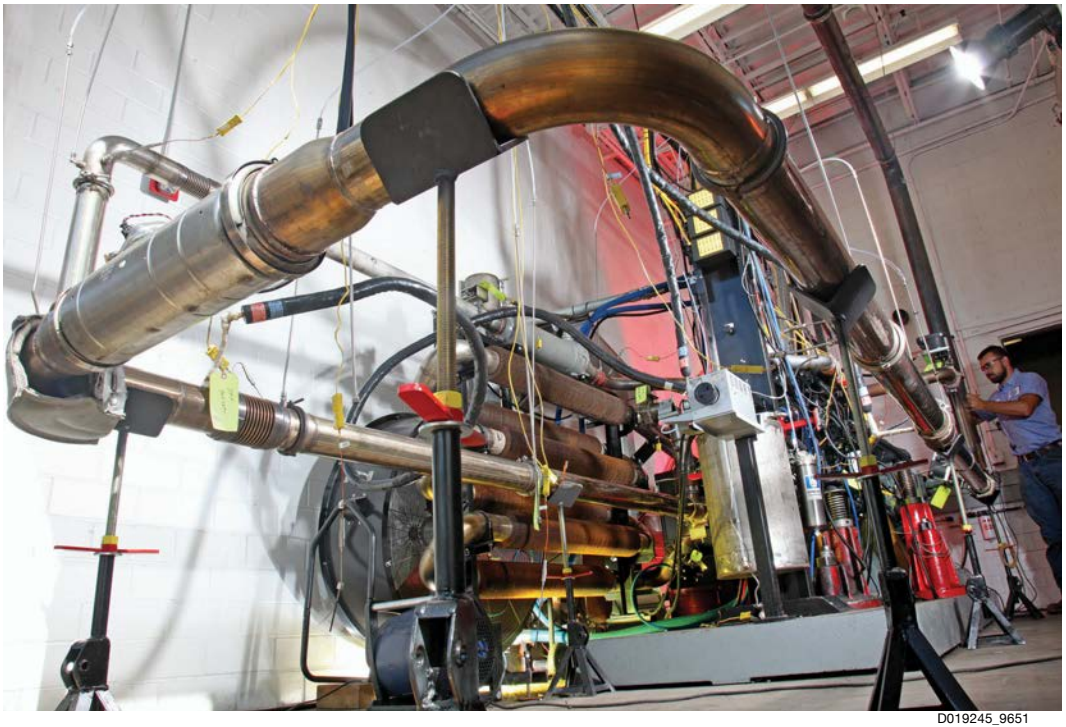
Internationally recognized for our locomotive engine research, we operate the world's largest independent large-engine research facility. Our comprehensive services address industry needs in alternative fuel evaluations, emissions research, engine performance improvement and more.


D018844_7351

Our bank of 24 road simulators, operating at speeds up to 100 miles per hour, help evaluate the durability and performance of automotive fluids, fuels, components and emission control systems (fueleconomytesting.swri.org). One dynamometer has four-wheel-drive capabilities that also support hybrid vehicle testing under real-world conditions. Four dynamometers have temperature- and humidity-controlled engine inlet air to ensure consistent operating conditions year-round. Another high-performance dynamometer supports vehicles up to 400 horsepower.

SwRI operates facilities around the clock to ensure that our clients' engine and aftertreatment systems comply with emissions standards. To earn certification, products must demonstrate emissions compliance over the designated full useful life of the system — as much as 22,000 hours of operation for some applications. Our facility logged more than 20,000 hours of operation in 2013 in support of such programs.

Our staff operates the U.S. Army TARDEC Fuels and Lubricants Research Facility (TFLRF), a government-owned laboratory providing dedicated service to the Army fuels and lubricants technical program (tardec.swri.org). Work completed ranges from basic research to applied testing and evaluation in Army vehicles and equipment. Current research areas include developing a single common powertrain lubricant, investigating compatibility and performance of novel alternative fuels, and developing advanced bulk modulus testing capability to support future work within the Army and industry. ❖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We developed a flexible stand that provides capabilities to test diesel aftertreatment components and systems with highly repeatable operation to develop emission system calibration and hardware evaluation strategies.

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 and Vice President Steven D. Marty, P.E., at (210) 522-5929 or steven.marty@swri.org.

Automation and Data Systems

- unmanned ground vehicles
- robotics
- intelligent transportation systems
- embedded systems
- 3-D sensing & perception
- tactical networks
- process improvement
- situational awareness
- automated inspection
- aerospace networks
- process re-engineering
- control center software
- image & signal processing
- high-reliability software
- machine vision
- ROS-Industrial
- embedded systems security
- tactical communications
- specialized sensing systems
- automated vehicles
- connected vehicles
- perception systems
- high-performance computing
- lean manufacturing
- network-centric systems
- advanced manufacturing
- energy efficiency
- predictive analytics
- smart energy technologies
- data mining

D019360

SwRI's novel stereo-vision pedestrian detection system can locate people in the vicinity of a vehicle. This system delivers state-of-the-art performance from a moving platform, operating in real time (ivs.swri.org).

Southwest Research Institute uses the latest technology to create next-generation systems for applications ranging from robotics and automation to advanced networks, intelligent transportation and unmanned ground vehicles.

This year, we extended the capabilities of ROS-Industrial, an SwRI-led open-source project that extends the advanced capabilities of the Robot Operating System (ROS) software to new industrial applications. We launched the ROS-Industrial Consortium, a membership organization providing cost-shared applied research and development for advanced factory automation. We also are developing a ROS-Industrial framework to provide automated generation of robot paths for industrial applications (rosindustrial.swri.org).

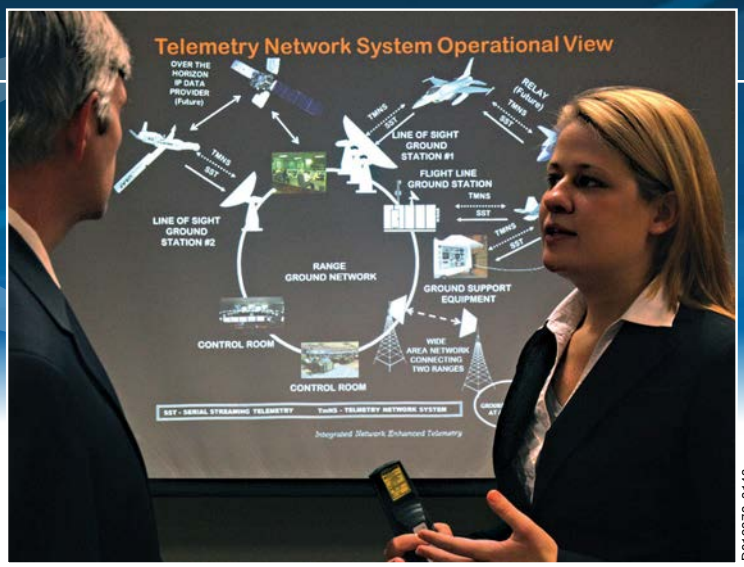
In 2013, specialists in automation, signal exploitation and geolocation helped the Electric Power Research Institute develop robots for three applications aimed at providing safe, efficient, automated remote monitoring and inspection for the electric power industry. At the EPRI outdoor field test loop, we demonstrated a breakthrough technology, a high-voltage transmission line inspection robot. For the second application, a robot crawls the length of an insulator while performing autonomous, safe and repeatable measurements of electrical integrity. For the third application, a crawling robot integrates sensing and 3-D positioning technology for automated inspection of concrete infrastructure such as dams and containment domes (robotics.swri.org).

SwRI recently demonstrated a novel vehicle-to-grid aggregation system, which expands the role of electric vehicles. The electric transportation fleet also serves as a backup energy source while more effectively integrating power generated by solar arrays (smartenergygrid.swri.org).

Courtesy Boulder Electric Vehicle

D019315

After defining the integrated Network Enhanced Telemetry (iNET) architecture and standards, SwRI is leading the deployment of the first iNET systems at select range and test facilities, which will revolutionize the way the military evaluates new aircraft and ground vehicle systems (telemetry.swri.org).



D019272_3143

The advent of infotainment systems has transformed today's already highly computerized vehicles into rolling computers on the Internet. These systems, and the connectivity they provide, bring new levels of capability and information into the car but, like all networked systems, are vulnerable to hackers. To safeguard these systems, SwRI is developing techniques to protect against hacking as well as to identify system bugs and protect the intellectual property associated with vehicle control software (aces.swri.org).

In 2013, SwRI completed a five-year contract defining the architecture and developing standards for the integrated Network Enhanced Telemetry (iNET) program, the most significant technology and paradigm update to the Department of Defense's range and test facilities in more than 50 years. Revolutionizing telemetry for the military research, test and evaluation community, iNet's new radio spectrum-enhancing capabilities will save time and money in the testing environment (telemetry.swri.org).

Specialized communications work has seen a resurgence this past year. Combining smart energy, RF communications and cyber security capabilities, SwRI is developing novel solutions to overcome GPS vulnerabilities affecting devices such as synchrophasors, which help utilities accurately measure the state of the electrical system and manage power quality.

SwRI-developed onboard data acquisition and recording systems remain the state of the art in real-time flight test data instrumentation. We continue extending capabilities to support flight testing of future airframes (aits.swri.org).

We have developed and deployed a predictive analytics system called Picture It Settled® to help parties and their attorneys settle cases. Combining a continuously expanding database of litigated cases with negotiation techniques, the system facilitates the mediation and negotiation process, providing intelligence to tighten strategies and achieve improved outcomes (dst.swri.org).

As a pioneer in intelligent transportation technology, SwRI's advanced traffic management software operates in more than 40 traffic management centers, integrating more than 10,000 intelligent transportation system devices along urban and rural highways in Texas and Florida. We recently were selected to provide system software for three additional states. In related research, we are deploying vehicle-to-infrastructure and vehicle-to-vehicle communications to support active safety systems in maintenance and commercial fleets (its.swri.org).

We also are pioneering unmanned ground vehicle research, developing low-cost electro-optical sensor technology fused with autonomous cognitive behaviors to allow a full-sized tactical military vehicle to perform autonomous resupply missions. With our expertise in connected vehicle and UGV technologies, SwRI is emerging as the leader in connected autonomy research (ivs.swri.org). ❖

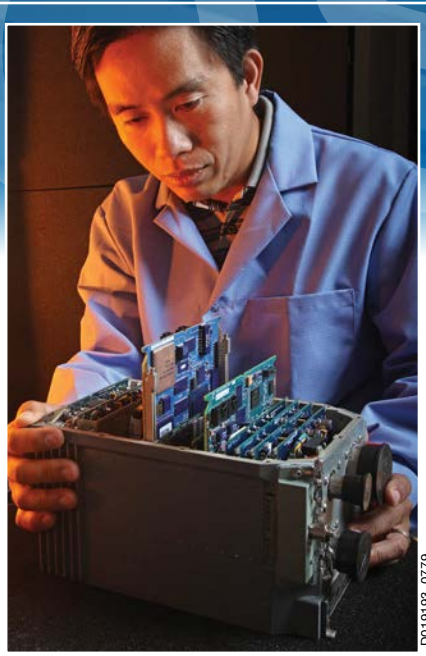
Visit autodata.swri.org for more information or contact Vice President Susan Crumrine at (210) 522-2089 or susan.crumrine@swri.org.

D019278_5168

Using 3-D sensing technologies and dynamic path planning algorithms, SwRI is addressing issues associated with automation in unstructured environments. Applications range from mobile robotics in factories and warehouses to complex sorting tasks for recyclables or parcels.

Aerospace Electronics, Systems Engineering and Training

- unmanned aerial vehicles
- foreign military sales (FMS)
- turbine engine diagnostics
- ORACLE® databases
- flight controls
- trigger-based management
- natural language interfaces
- A-10 programs
- automatic test program set development
- flight-line testers
- re-engineering electronics for F-16 aircraft
- aircraft data recorders
- unmanned ground vehicles (UGV)



D019193_0779

The SwRI-developed Improved Electronic Processing Unit combines engine turbine monitoring and aircraft structural integrity systems into a single, consolidated line replaceable unit that will be installed in the entire A-10C fleet.

Southwest Research Institute specializes in overhauling and modernizing aging electronic aerospace systems, particularly for the U.S. military. We also streamline maintenance processes and develop new sustainment technology, in addition to providing custom training and computer systems for government and industry clients.

For the last 20 years, SwRI has played a critical role in revamping the A-10 Thunderbolt into a multifunctional digital weapons system. We have designed and produced a series of monitoring systems for engine and aircraft structural components, allowing cost-effective condition-based maintenance on individual aircraft based on flight data and pilot handling. The latest version of the Improved Electronic Processing Unit, IEPU-50, uses an Ethernet interface to support high-speed data download and re-programmability as well as hardened electronics to withstand harsh flight conditions. SwRI is supplying IEPU-50s for every jet of the existing A-10C fleet to improve diagnostic and troubleshooting capabilities and identify further advances. Our engineers also designed and developed IEPU-50 production testing specifications and software test sets to support depot-level maintenance and repair of the device (aircraftsystems.swri.org).

In parallel with IEPU-50 production, our engineers performed design, development and testing of on-aircraft Ethernet wiring modifications for the A-10C, reusing existing cable paths and aircraft components to minimize weight and structural changes. Engineers also re-hosted existing software applications used by avionics and engine technicians into a single application, the Aircraft Systems Information Support Tool (ASIST), which uses an Ethernet interface with monitoring devices. The new ASIST application

Courtesy Alliant Techsystems

To help weapons systems strike targets more accurately, SwRI designed fire-control software for a commercial supplier of military gunships. We used advanced, real-time ballistic algorithms to optimize performance and reduce errors (aerospaceengineering.swri.org).

Combining SwRI's nSPCT™ multivariate statistical analysis tool with existing trending tools improves early detection of performance changes in the turbine engines of F-15, F-16 and A-10 aircraft, reducing overall operational costs and increasing mission readiness (nspct.swri.org).

allows technicians to troubleshoot engine-related failures quickly and efficiently, reducing maintenance downtime and improving aircraft availability.

Aircraft situational awareness systems are networked radio, communications and data systems that allow air-to-air, air-to-ground and ground-to-air communications, providing a solution to the long-standing air-to-ground combat identification problem. In 2013, SwRI developed a consolidated communication systems support kit for the A-10, which allows quick, accurate and non-invasive operational checkouts as well as more thorough trouble-shooting to diagnose and isolate failures. Using this kit significantly decreases maintenance time, reducing costs and improving aircraft availability. A similar kit was developed to support the C-130 Hercules military transport aircraft, allowing technicians to load configuration parameters, set up and adjust network control parameters and perform testing (avionics.swri.org).

Because the effectiveness of the modern fighting force depends on training, SwRI electronic warfare specialists are upgrading Air Force systems used to simulate enemy radar and missile threats. We redesigned three emitter systems used in pilot training leveraging the latest electronics and developed an extensive line of practical, effective threat radar simulators for combat training and test ranges. The systems can be structured to simulate early warning radar, shipboard anti-aircraft artillery and missile fire control radar (ew.swri.org).

In addition, SwRI training specialists have developed a novel method for authenticating a computer user's identity using covert games disguised as Windows® alert messages. The method applies game theory principles as users develop unique strategies for "playing" the "games," while the real intent of the interaction remains imperceptible. The approach complements other cognitive fingerprint detection methods and could help increase overall accuracy of such systems, especially when combined with biometric identification techniques. ❖

Visit aerospaceelectronics.swri. org for more information or contact Vice President Richard D. Somers at (210) 522-3188 or richard.somers@swri.org.

D019231_7150

SwRI developed and installed new simulation stations to train troops to identify problems with helicopter engines on the flightline. Features include simulated cockpit displays and fault insertion as well as recording students' actions for evaluation (aerospaceservices.swri.org).

Mechanical Engineering

- computational fluid dynamics
- deep ocean simulations
- fracture mechanics
- flow measurement
- multiphase flow
- probabilistic failure analysis
- environmental testing
- surface engineering & coatings
- telecommunications evaluations
- structural mechanics
- failure analysis
- eddy current modeling
- diagnostic software
- thermal & corrosion analysis
- nondestructive evaluation
- pipeline compression
- acoustics
- biomechanics & biomaterials
- magnetostrictive sensors
- materials integrity & life prediction
- terminal ballistics
- guided wave inspection
- aerodynamics
- propellant dynamics

D019204_2365

SwRI develops surface modification and coating technologies to improve the performance of materials. New low-temperature deposition processes, shown here, could improve the surface properties of various military components such as rotor blades, infrared missile domes and photovoltaics (surface engineering.swri.org).

With expertise in materials, structures, sensors, fluids and energetic systems, Southwest Research Institute helps clients improve system safety, reliability and efficiency while extending the lives of these systems. Core areas of mechanical engineering research include oil and gas production and transmission; renewable energy; military and commercial aircraft; underwater systems; space hardware; and military vehicle armament.

In 2013, we initiated several Defense Advanced Research Projects Agency programs aimed at slashing the time it takes military vehicles — both ground and aircraft — to go from concept to production. In one project, ballistic and blast protection survivability models for ground vehicles are integrated into the overall design and production to address in real time how changes in armor and weight would affect, for instance, overall engine requirements (engineeringdynamics.swri.org). For another, we enhanced advanced materials manufacturing for composite aircraft structures (mateng.swri.org). In a complementary program for the Air Force, we optimized composite materials, manufacturing processes and component designs, modeling the production from design to deployment.

While supporting research to expand the use of composite airframes and new reusable launch vehicles, we continue supporting the military's need to extend the structural lives of existing aircraft. SwRI engineers measure how fleets — such as the T-38, the A-10 and other aircraft — are flown, providing modeling for analyses, developing life extension strategies and confirming utility with full-scale fatigue testing. We also develop new nondestructive inspection technology and analyze unconventional repair techniques on legacy aircraft, allowing these fleets to safely fly decades past their originally intended design life (aerospacestructures.swri.org).

SwRI continues to play a role in the safe and efficient production and transport of oil and natural gas. Our high-pressure simulation facilities are operating at capacity, including five new high-pressure, high-temperature chambers, evaluating and qualifying new equipment for safe operations under extreme conditions

D019192_6872

SwRI helped develop this unique closed-loop compressor to support a Department of Energy greenhouse gas reduction project aimed at reducing costs associated with carbon sequestration (machinery.swri.org).

D019299

Using large-scale numerical simulations, SwRI is evaluating how military vehicles are affected by land mines or improvised explosive devices and simulating the effects on soldiers within. We monitor the acceleration levels occupants experience with the goal of minimizing injuries (engineeringdynamics.swri.org).

(deepoceansimulation.swri.org). Also operating at full capacity are extensive facilities evaluating the high-temperature and high-pressure performance of new materials in hazardous environments, such as those containing hydrogen sulfide and carbon dioxide (materialperformance.swri.org). A new centrifugal gas compressor is addressing wet gas compressor testing. SwRI is also pioneering strategies to address safety, costly blockages and corrosion fatigue in piping and drilling systems (fluids.swri.org).

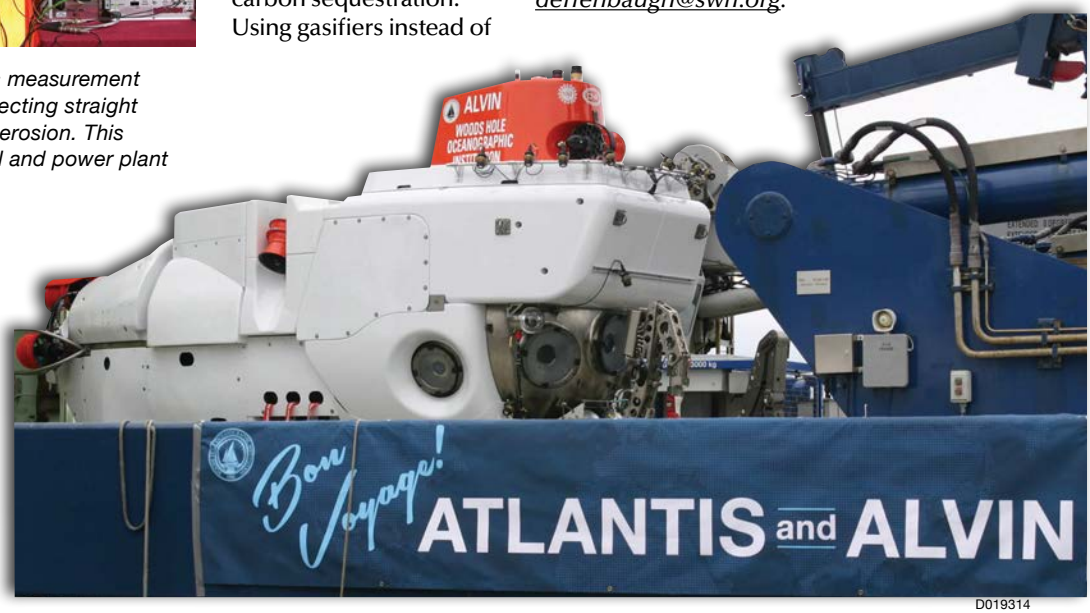
Support for green energy includes four major Department of Energy projects to improve efficiency and advance solar power, supercritical CO_2, clean coal and carbon sequestration technologies. In concentrating solar energy arrays, we are improving cycle efficiency by replacing the working fluid — such as steam — with supercritical CO_2 and air systems. To take advantage of the properties of supercritical CO_2, SwRI is designing a high-temperature, high-pressure closed-loop gas turbine, where very high thermal efficiencies could significantly increase power production per fuel unit. In addition to cost savings, improved cycle efficiencies also decrease environmental impact. In cooperation with the National Energy Technology Laboratory, we also are developing new technology for clean coal applications to decrease parasitic losses associated with carbon sequestration. Using gasifiers instead of conventional furnaces, coal is converted to hydrogen-rich gas, which produces electrical power in combined-cycle gas turbines, allowing the waste CO_2 to be more efficiently captured, compressed and injected into geologic storage. This field of work is also enhancing SwRI capabilities in turbomachinery and combustion testing for conventional energy applications (machinery.swri.org).

SwRI is developing magnetostrictive sensor technology for a wide range of applications including pipe, tank bottom, cable and vessel inspection and monitoring. SwRI developed and evaluated this technology in conjunction with synthetic aperture focusing technology for application to power plant containment shells. The technology is particularly relevant to re-licensing nuclear power plants and is presently being evaluated in Switzerland (ndesensors.swri.org). ❖

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

DM019030_0888

A newly developed piping thickness measurement system is a hybrid approach to inspecting straight and curved pipes for corrosion and erosion. This technology is used in petrochemical and power plant facilities (ndesensors.swri.org).



D019314

A new titanium personnel sphere — designed, fabricated and tested by SwRI to reach 98 percent of the ocean floor — was integrated into the Alvin *research submersible.* Alvin *has been deployed on the research vessel* Atlantis *for additional system-level certification (marinestructures.swri.org).*

Space Science and Engineering

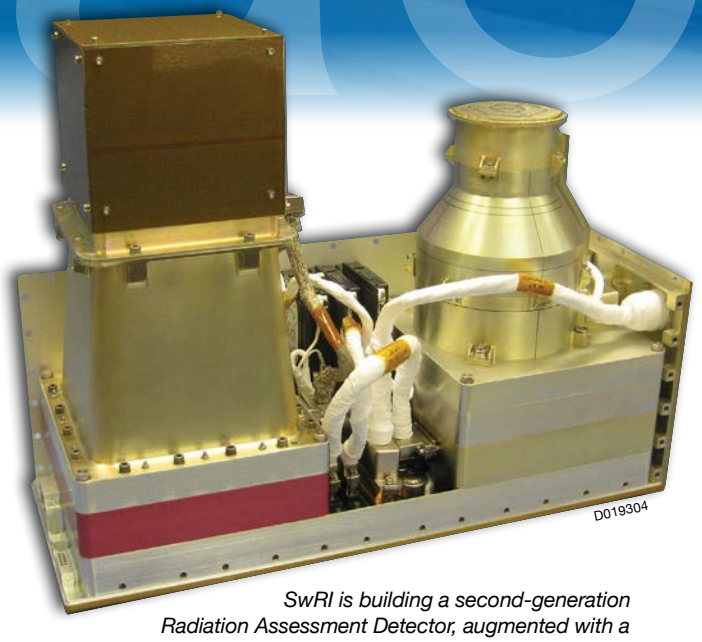
- spacecraft instrumentation
- spacecraft avionics
- electromechanical systems
- power systems
- microsatellite design, development & fabrication
- spacecraft management
- lighter-than-air systems
- terrestrial and planetary magnetospheric physics
- solar & heliospheric physics
- planetary science
- data analysis & science support
- science & mission operations

For more than 30 years, Southwest Research Institute has been 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.

We specialize in developing instruments to measure charged particle populations in various solar system environments, as well as ultraviolet imagers to remotely sense planetary and satellite atmospheres and surfaces. SwRI-developed plasma instruments are flying on NASA's Juno mission to Jupiter and New Horizons mission to Pluto, as well as on the European Space Agency's Rosetta comet mission.

SwRI leads the science investigation and development of the complete instrument payloads for NASA's four-spacecraft Magnetospheric Multiscale mission. Hot Plasma Composition Analyzers built by SwRI have been successfully integrated into the MMS spacecraft, scheduled to launch in 2014.

We are currently leading development of particle instruments for two solar physics missions, the European Space Agency's Solar Orbiter, launching in 2017, and NASA's Solar Probe Plus, launching in 2018. In addition, SwRI has been selected to build the ultraviolet imaging spectrograph for ESA's Jupiter Icy Moon Explorer mission, launching in 2022. Similar SwRI-developed UV instruments are on Juno, New Horizons, the Lunar Reconnaissance Orbiter and Rosetta.

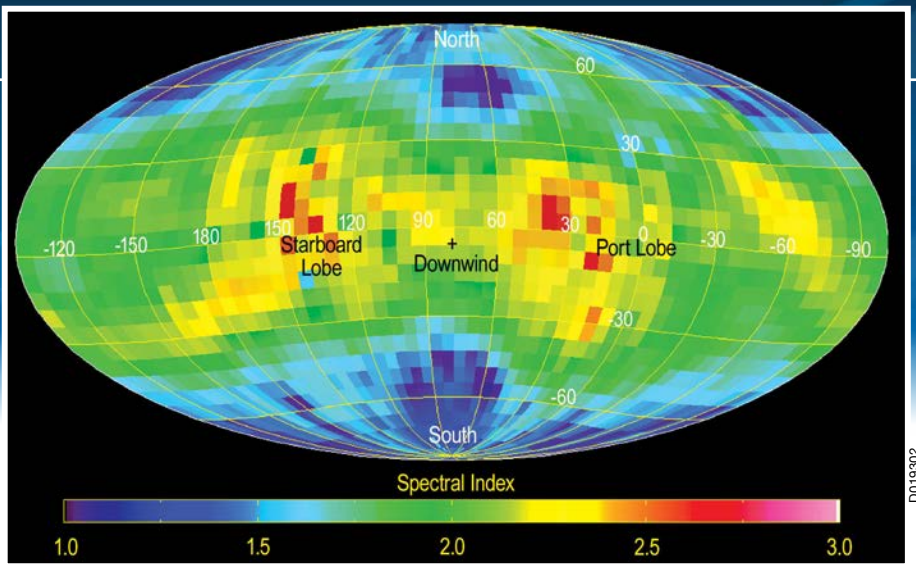

D019304

SwRI is building a second-generation Radiation Assessment Detector, augmented with a fast neutron detector, for deployment on the International Space Station in 2014. The original RAD instrument on NASA's Mars rover Curiosity successfully established the baseline radiation dose for future manned missions to Mars.

SwRI researchers are developing innovative mass spectrometers to study planetary, satellite and cometary environments, including a Laser Desorption Resonance Ionization Mass Spectrometer geochronology instrument that can be used for *in-situ* dating of Earth's and other planetary surfaces. Integration, testing and calibration of SwRI's Strofio neutral mass spectrometer for ESA's Bepi-Colombo mission to Mercury, launching in 2016, have been completed, and SwRI has received


D019305

For NASA's Magnetospheric Multiscale mission, SwRI oversees integration and testing of more than 100 instrument elements from a dozen different institutions. Shown here is one of four MMS satellites following integration of the instrument deck with the spacecraft bus and installation of the solar arrays at NASA's Goddard Space Flight Center.



The SwRI-led Interstellar Boundary Explorer mission provided the first look at the structure of the "tail" of the heliosphere, the giant cavity inflated in the interstellar medium by the solar wind. As shown in this sky map (high spectral index shown by color scale), a twin-lobed sheet of slow solar wind plasma at middle and low ecliptic latitudes is sandwiched between fast solar wind regions (low spectral index) toward the poles. The view is from Earth down the tail.

Courtesy McComas et al. [ApJ, 2013]

technology development funding from NASA for a mass spectrometer targeted for a future mission to Jupiter's moon Europa.

Our scientists are active in a number of different areas of space research, including the study of planetary and satellite surfaces and atmospheres, investigations of Earth's and other planetary magnetospheres, as well as probing the outermost boundaries of the heliosphere. Significant scientific accomplishments during 2013 include the discovery that Mercury was completely resurfaced by volcanism about 4 billion years ago, the same time the Moon experienced a major bombardment of its surface. We also measured the radiation exposure that future astronauts may experience on a trip to Mars and made new discoveries about the global structure of the heliosphere and the solar system's immediate interstellar environment.

NASA's Cyclone Global Navigation Satellite System project, which SwRI is managing under contract to the University of Michigan, successfully completed its Systems Requirements Review. In addition to overall project management, SwRI is building the eight CYGNSS spacecraft and will conduct mission operations. This project represents a significant new direction for SwRI into the area of microsatellite development.

SwRI's space engineering and electronics program experienced significant growth during 2013, with a 33 percent expansion of our client base enabled by internal research investments in high-performance spaceflight processors, power electronics and Ethernet for space. Projects include a first-generation spacecraft control system based on Ethernet connectivity, ultra-high performance data bandwidth management systems such as the Image Rate Buffer for the Naval Research Laboratory, advanced crosslink communication and software-defined radios, and flight electronics for the Dream Chaser® manned space flight vehicle.

In the area of lighter-than-air technology, we successfully demonstrated a fully automated Tactical Aerobot Launch System and teamed with the University of Arizona on a NASA-funded feasibility study for a balloon-borne suborbital telescope for radio astronomy observations up to submillimeter wavelengths. ❖

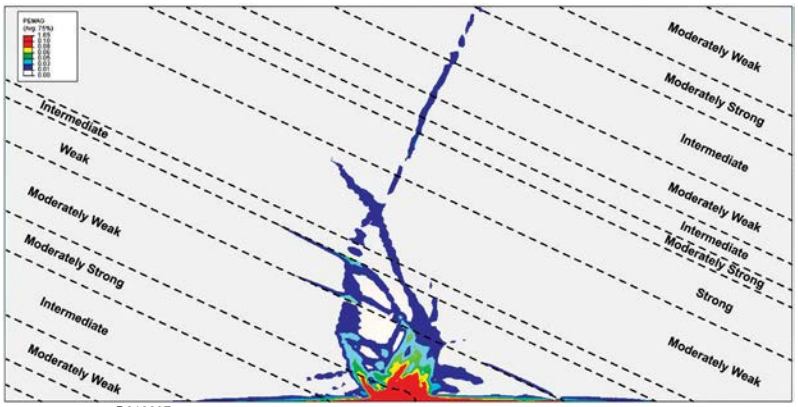
Visit spacescience.swri.org for more information or contact Vice President Dr. James L. Burch at (210) 522-2526 or jim.burch@swri.org.

Courtesy NASA

SwRI has been selected to provide the flight control computers and actuator control unit for the Dream Chaser, one of three next-generation commercial space transportation vehicles being developed to replace the space shuttle. This is the first computer system developed by SwRI for manned space applications.

Geosciences and Engineering

- geophysical & geological investigations
- groundwater resource evaluations
- geological structure analyses
- energy exploration
- chemical & radiological contaminant transport
- laboratory, field & numerical analyses
- corrosion & materials life prediction
- risk & performance assessments
- environmental impact assessments
- geoscience processes
- structural integrity analyses
- reliability & operational safety analyses
- planetary science
- regulatory analysis & guidance
- fire protection & forensic analyses
- material aging & degradation
- natural & human-induced hazard assessments
- pipeline failure analysis
- probabilistic risk assessment
- radiation health physics



D019297

Numerical modeling allows scientists to explore how geologic structure, mechanical layering and in-situ *stress influence rock failure mechanisms, as well as explore the reach and interconnectivity of induced hydraulic fracturing, critical factors in the recovery of hydrocarbons from self-sourced reservoirs.*

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 (CNWRA®) to support the Nuclear Regulatory Commission in fulfilling its regulatory responsibilities related to radioactive waste disposal and other aspects of the back end of the fuel cycle. In addition, NRC provided the Center with additional work from the front end of the fuel cycle that supports the Center's special competencies in waste management. This work addresses the entire nuclear fuel cycle, including radioactive waste management regulation and associated research.

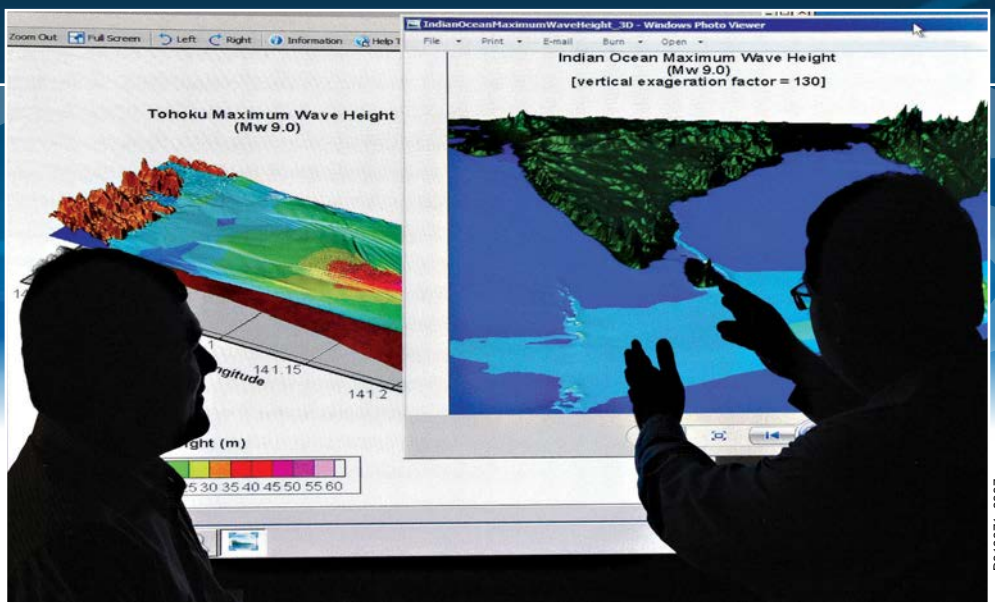
In 2013, we supported NRC environmental and safety evaluations for uranium extraction and processing, nuclear materials enrichment and fuel fabrication facilities. We also supported reactor license renewals and evaluated the use of small modular reactors and storage of used nuclear fuel in pools and dry casks in areas related to Center special competencies. CNWRA scientists also conducted preliminary research in spent nuclear fuel reprocessing (cnwraweb.swri.org). Our expertise was applied to radioactive waste management programs in Asia and Europe, as well.

For the petroleum industry, we continue to market and improve our award-winning 3D Stress® software (3dstress.swri.org), a tool supporting fossil fuel exploration and production, including evaluation of conditions associated with


D019298

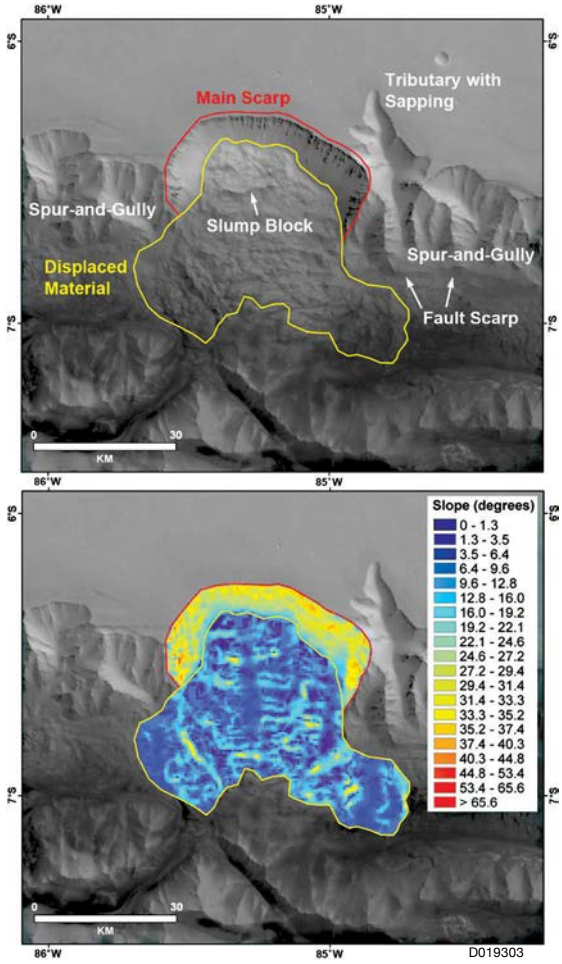
SwRI geologists map natural fractures in the "rock pavements" of the Eagle Ford Shale Formation to better understand how mechanical rock properties affect fracturing and hydrocarbon production in the Eagle Ford and other self-sourced reservoirs.

In 2013, we expanded our natural hazard assessment work for critical infrastructure. Using computational fluid dynamics, our scientists have developed integrated approaches to model seismically generated tsunamis and their impact on coastal structures such as petrochemical and nuclear facilities.



induced hydraulic fracturing ("fracking") of production wells, as well as applications to geothermal energy production in the U.S. and abroad. We also are expanding the range of our geologic training courses, locations and topics to help the oil and gas industry better understand how geology affects the trapping, compartmentalization and production of fossil fuel reservoirs. In 2013, scientists conducted cross-section restoration, stress analyses and geomechanical modeling for unconventional as well as conventional reservoirs in North America and around the world.

SwRI's Eagle Ford Shale joint industry project added four new participants, bringing the total to 10 member companies. The project studies how mechanical properties of rock layers affect fossil fuel reservoirs, particularly "self-sourced" reservoirs. Conventional reservoirs are characterized by porous rock layers where oil or gas accumulates after migrating from an organic-rich source rock, such as mudrock; hydrocarbons are produced by conventional well drilling. Self-sourced reservoir formations comprise both the source rock and reservoir. Because mudrock layers are inherently tight, they require hydraulic fracturing to create enough porosity and permeability to extract the hydrocarbons. This project is studying how natural deformation — such as faulting, fracturing and folding — as well as induced fracking, affect hydrocarbon production from the self-sourced Eagle Ford Formation in South Texas.



Like oil and gas, groundwater is another critical resource, particularly in the state of Texas. SwRI is developing an alternative groundwater availability model for the Edwards Aquifer Authority and conducting several other projects with water management entities across Texas (hydrology.swri.org).

Applying Earth science expertise to other planets, we conducted physical analog modeling of dike intrusion and faulting on Mars, as well as data analysis and numerical modeling to understand Martian debris flows, landslides and sand dunes (analogmodel.swri.org).

We transferred our expertise in assessing how materials, such as metals or pollutants, travel through complex geological strata and, in an innovative way, applied it to microparticles moving through biological tissues. SwRI researchers validated a numerical model using experiments involving microparticles flowing through an obstructed microchannel. Our unique model simulates the migration of nanoparticles in a fluid within geometrically complex flow channels to understand and optimize delivery of nanomedicines to, for example, target cancers. ❖

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 high-resolution Martian image data and geomorphologic characterization, SwRI scientists successfully modeled a large landslide, demonstrating that discrete element modeling can be a powerful tool for investigating landslide processes on both Earth and Mars (planetarygeosciences.swri.org).

Signal Exploitation and Geolocation

- analysis, analytics, visualization & reporting
- antennas & propagation
- array processing
- cloud computing
- combat identification
- signal processing
- communications solutions
- cross-domain solutions
- electromagnetic modeling
- electronic attack
- electronic warfare
- genetic programming
- intelligence networking
- GPS engineering
- high-performance computing
- information exploitation
- geolocation
- information operations
- life-cycle support
- signals intelligence
- micro-SIGINT
- steganalysis
- surveillance systems
- tagging, tracking & locating solutions
- situational awareness
- intelligence, surveillance & reconnaissance
- RF design

D019248_9898

We recently qualified our AS-140 high-frequency direction finding shipboard antenna. SwRI provides lifetime technical support for its systems, including onsite antenna installation, training, testing and repair (tpd.swri.org).

With the proliferation of modern communications signals and crowding of the radio frequency spectrum, signal interference is an ever-increasing problem. Southwest Research Institute is at the forefront of signals intelligence advances, developing complex antenna arrays and using sophisticated signal processing techniques to separate and exploit signals of interest.

The military, law enforcement and homeland security communities are especially interested in exploiting signals data from strategically important sites. Complicating these efforts is the tremendous volume of signals data, which has made gathering meaningful intelligence exceedingly time-consuming.

Our portable, yet highly capable system for supporting radio frequency surveys, called Scout™, allows survey teams to detect signals, locate their source and interpret their significance. Scout color codes the arrival direction of signals, enabling analysts to quickly identify energies from threat areas. Analysts also can reconstruct signals of interest occurring up to 24 hours in the past. Future enhancements of the system include the addition of constrained bandwidth operation, signals overlay and multisite capabilities (sigintsolutions.swri.org).

SwRI is leading efforts to replace the worldwide angle-of-arrival direction finding network, which has operated for decades with few hardware and software upgrades. We are analyzing and improving geolocation fix algorithms, and

Courtesy TSgt Effrain Lopez, U.S. Air Force

There are multiple UAV platforms for SwRI's COMINT and geolocation systems. Platforms capable of supporting SwRI systems include the Predator.

D019175_8904

The highly successful SwRI HF/VHF/UHF band AU-506B Submarine COMINT ES antenna has been updated with greater sensitivity and frequency coverage to exploit modern UHF radio communications signals. The AU-506 series of antennas has been deployed around the world since 1992, providing radio direction finding and intercept of communications signals. The AS (Antenna Surface) variant has been used on land mobile, shipboard and other platforms.

supporting improved geolocation network performance for improved user access to operational and strategic data (sed.swri.org).

SwRI designs and develops radio direction finding antennas in multiple frequency ranges for both shipboard and land-mobile applications (tacticalproducts.swri.org). This year, our engineers delivered systems for the Royal Navy Communications-band Electronic Support Measures program and the Royal Australian Navy Air Warfare Destroyer program. We also integrated communications intelligence and electronics intelligence antennas for the Royal Australian Navy Anzac-class frigate upgrade program.

We support the United States government and its allies with communications intelligence and geolocation capabilities on unmanned aerial vehicle platforms. Staff members support the full life cycle — design, development, deployment and sustainment — for these systems on a variety of platforms, providing world-class capabilities in extremely small packages ideal for UAVs (productengineering.swri.org).

For decades, SwRI has used internal funding to advance technologies that benefit our clients. Efforts have targeted dynamic geolocation in challenging environments, the feasibility of upgrading legacy electronic warfare pod radio frequency processing components for modern threats, and novel concepts for a meta-material phase shifter for small transmit-and-receive phased arrays.

Working with SwRI space systems engineers, we developed and demonstrated four terrestrial prototype transceivers. NASA, the Department of Defense and SwRI internal research funded the satellite radio frequency systems program (surveillance.swri.org).

Signal exploitation and geolocation research, design and production services are certified to the international standard ISO 9001:2008 and the Software Engineering Institute's Capability Maturity Model® Integration, Level 3, to assure the highest quality products and services for clients. ❖

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

D018916_2863

Our compact portable system, Scout, allows analysts to scan a potentially hostile area's radio spectrum and locate a variety of signal sources. Scout systems have been deployed worldwide.

Applied Physics

- digital & analog electronics
- RF systems
- electromechanical systems
- micro-power circuitry
- sensors
- microbiology
- virology
- cell biology
- metamaterials
- nanomaterials
- lasers, optics & electro-optics
- acoustics & ultrasonics
- biometric systems
- non-lethal weapons
- MEMS
- robotic vehicle evaluations
- failure analysis
- rapid prototyping
- miniaturization technologies
- geophysics

D019270_1643

SwRI developed a lightweight gas turbine generator for an unmanned aerial vehicle. Combined with an electric propulsion system, the design allows the UAV to reach distant targets, while allowing nearly silent operation at the mission site.

With a diverse staff and world-class expertise, Southwest Research Institute pushes the boundaries of engineering and physics to create advanced technologies and systems in leading-edge facilities to meet our clients' challenging demands. We also evaluate novel robot systems and develop algorithms to expand the range and application of materials and systems.

To support initiatives to make solar energy more cost-competitive, SwRI scientists are using system-based optimization strategies to advance concentrated photovoltaic solar technology, reducing the size, weight and cost-per-kilowatt hours by half over current technology. SwRI's proof-of-concept solar module achieves very high solar conversion efficiency — more than 30 percent — in a robust, reduced form-factor package.

D015264_0057

For more than 50 years, SwRI has conducted component analyses, methodically dissecting electronic, electrical and electromechanical devices to assess in-service failure or to evaluate construction quality and compliance to industry practices and specifications.

SwRI developed a lightweight gas turbine generator that provides electric or hybrid-electric propulsion for a small, stealthy unmanned aerial vehicle. Engineers custom-designed, built and tested a novel gas turbine to drive an electric generator. The gas turbine can be shut down, allowing nearly silent battery-powered hovering during the mission; afterward, the gas turbine can be restarted to fly the UAV back to the launch site.

SwRI also offers advanced capabilities in microbiology, cell culture and virology, combining chemical expertise with biological strategies to solve problems. In 2013, researchers developed a bioaerosol test rig and protocol to evaluate the efficacy of air cleaners against airborne pathogens

Our scientists evaluated the effectiveness of a variety of new disinfectant formulations against super-bugs and other bacterial, fungal and viral organisms.

D019286_6758

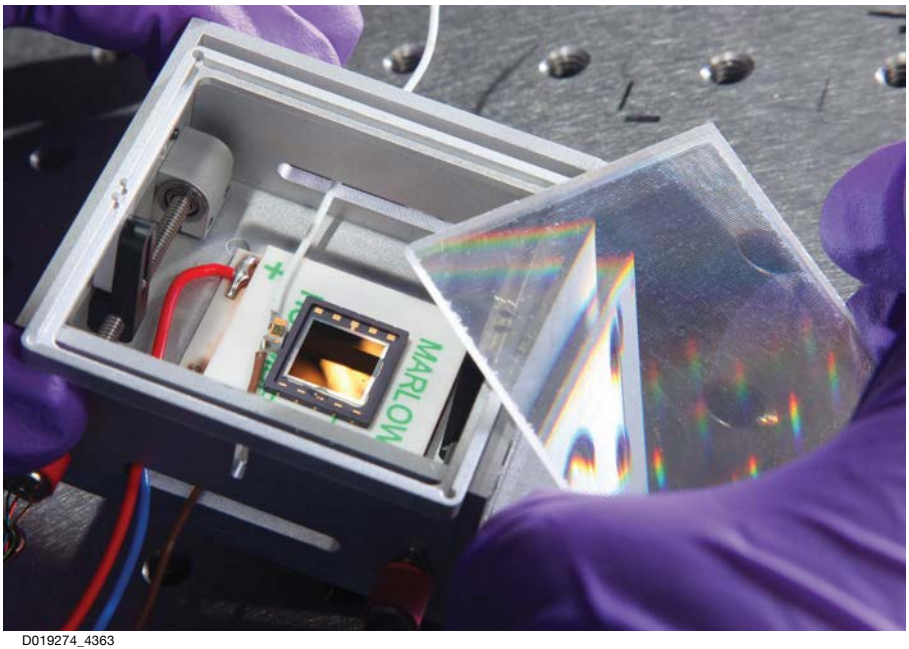
and irritants. To address microbial-induced corrosion, scientists investigated whether biocidal agents incorporated into primer coatings minimized fungal growth under normal conditions. For an Environmental Protection Agency exercise simulating a natural disaster with contaminated water supplies, SwRI worked with other laboratories to identify the suspected pathogen.

Natural or man-made disasters typically require human intervention; however, these situations are often risky and unsafe. The Defense Advanced Research Projects Agency is holding Robotics Challenge Trials to evaluate "humanoid" robots that could supplement or substitute for direct human activity in disaster environments. Working with the National Institute of Standards and Technology and DARPA, SwRI is developing and supporting test setups to evaluate the robots' human-like dexterity and mobility, among other capabilities.

In collaboration with researchers at The University of Texas at Austin, SwRI scientists are developing a new theory to describe the behavior of electromagnetic waves interacting with engineered composites, or metamaterials. We have discovered large magnetic and magnetoelectric properties that can be exploited to create new materials. Applications for such materials include exotic lenses, antennas and nanoscopic transmission lines for the next generation of electromagnetic components (advancedelectronics.swri.org).

For a multidivisional internal research project, scientists are supporting development of novel phase shifters by defining design limitations and engineering tradeoffs and analyzing different ways to push beyond state-of-the-art performance. Led by signal exploitation specialists, the project is developing shifters to steer beams of antenna arrays in, for example, geolocation and tracking applications. Because the shifters are low loss, they will not require the typical transmit and receive modules on each of multiple antennas in an array, greatly reducing the cost and complexity of such systems. ❖

Visit applied-physics.swri.org for more information or contact Vice President Ken Bennett at (210) 522-5242 or kenneth.bennett@swri.org.

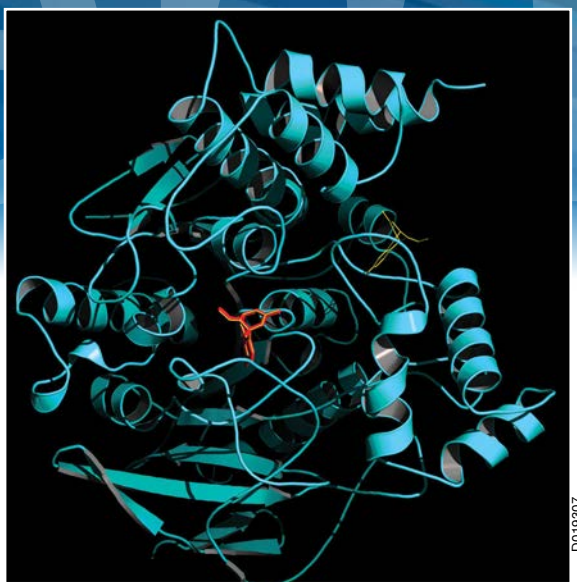


D019274_4363

SwRI's optimized solar module replaces expensive multi-junction cells with a spectrum concentrator that splits and focuses sunlight onto multiple inexpensive single-junction cells. Thermal harvesting and biologically inspired "moth-eye" coatings also enhance efficiency.

Chemistry and Chemical Engineering

- environmental engineering
- materials chemistry
- process engineering
- fire protection engineering
- analytical & environmental chemistry
- pharmaceutical chemistry
- homeland security
- environmental sampling
- analytical methods development
- health effects & epidemiology investigations
- risk & hazard analysis
- fire testing & research
- microencapsulation
- biomaterials engineering



D019307

SwRI chemists and high-performance computer specialists joined forces to develop Rhodium™ therapeutic drug development software, a tool to prescreen new drugs, such as a potential treatment for Alzheimer's disease (red), which interacts with a neural enzyme (cyan) (pharmdev.swri.org).

Southwest Research Institute develops advanced chemistry and chemical engineering solutions to help our clients meet global challenges in areas ranging from alternative energy to human health and safety. We develop novel pharmaceutical formulations and consumer product additives using unique capabilities in micro- and nanoencapsulation technology. Working with industry and government, we also develop new hydrocarbon processing technologies; support environmental studies; verify the safety of food, consumer and construction materials; and create new technologies to support homeland security.

SwRI chemical engineers are advancing production of cleaner renewable energy sources by building and operating pilot plants for new proprietary processes, such as ethanol to butanol. Many consider butanol the gasoline of the future because it offers 30 percent more energy per gallon and other advantages over ethanol, today's leading biofuel. We also designed and fabricated a pilot-scale system to produce diesel fuel from corn oil (biofuelprocessdev.swri.org). In 2013, we completed an 11-year pilot-plant demonstration converting natural gas to transportation fuel (chemeng.swri.org).

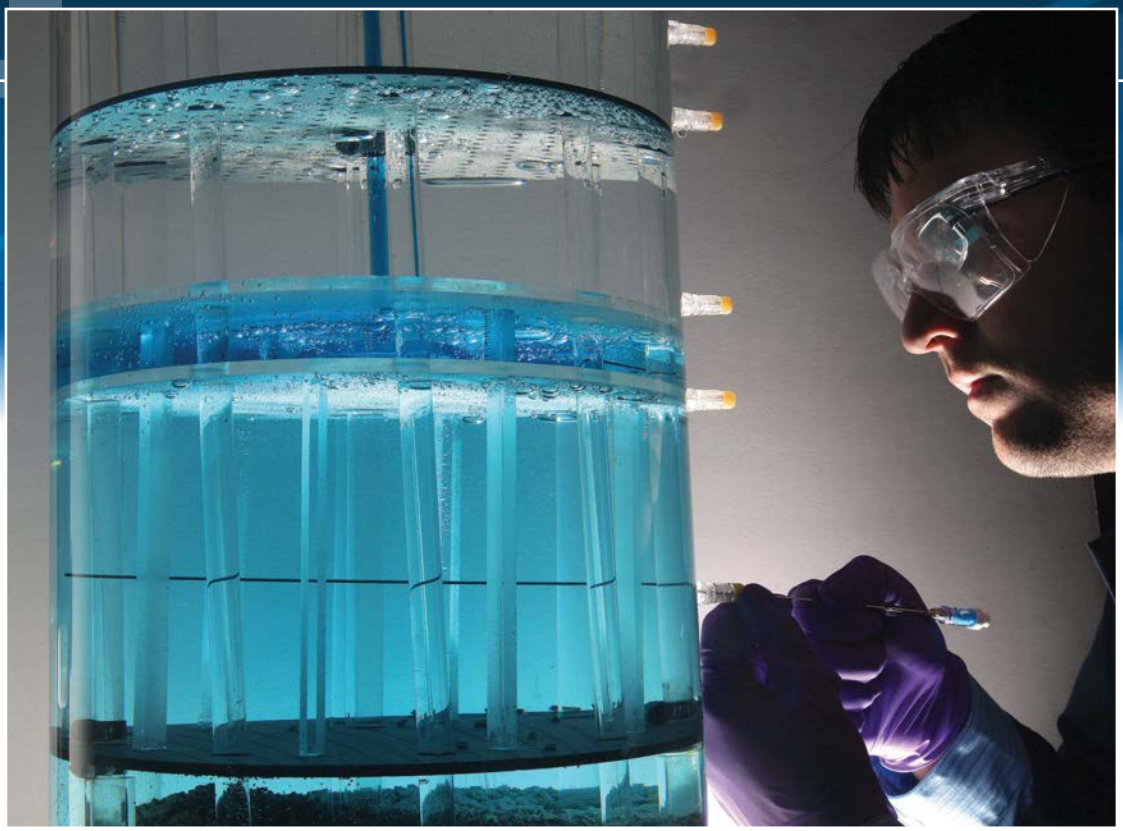
SwRI fire technology specialists conducted numerous experiments for a Discovery Channel program to solve the mysteries surrounding the Hindenburg disaster. Using a one-tenth scale model, engineers investigated theories about flame initiation and propagation in the 80-foot model airframe (fire.swri.org).

D019300

To help pharmaceutical companies develop and improve therapeutics, we are creating and synthesizing novel targeting and controlled-release drug platforms. These include nanoparticles that absorb near-infrared light and emit blue or ultraviolet light to activate a drug in the body and an injectable, controlled-release microsphere to treat arthritis (drugdelivery.swri.org).

In regenerative medicine, we are developing tissue engineering scaffolds and biomaterials loaded with therapeutics to accelerate bone, meniscus, skin, tendon and vascular regeneration (tissueeng.swri.org). We also are developing cutting-edge medical products such as nanoblood and organ preservation technology (matbioeng.swri.org).

SwRI is pioneering new medical countermeasures for chemical agents, including a novel cyanide antidote. We also are developing enzyme formulations as diverse as decontamination solutions for



D019276_5050

Using computational fluid dynamics and a transparent reactor model, chemical engineers and scientists are studying flow trajectories to help design a new refinery reactor to produce high-octane components for gasoline (chemeng.swri.org).

military vehicles without creating toxic runoff and prophylatic drugs to provide extra protection for warfighters against nerve agent exposure (synchemistry.swri.org). In the consumer products arena, we are developing new coating technologies for a contact lens manufacturer and encapsulating controlled-release formulations to provide nutritional supplements, taste masking and stability in food and beverages (microencapsulation.swri.org).

To support Japan's nuclear safety community, our fire technology specialists developed an innovative experimental protocol to demonstrate how fire might have spread in the electrical switch gear cabinets of nuclear power plants during recent earthquakes. This rocket-fuel-powered test setup provided the highly energetic conditions to simulate what actually happened in Onagawa, Japan, on the same day as the Fukushima event (fire.swri.org).

SwRI chemists 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 to characterize risks to human health and safety (environmental chemistry.swri.org).

For more than 26 years, SwRI supported our nation's efforts to dispose of chemical weapon stockpiles. We initiated our demilitarization laboratory, environmental and work place monitoring programs in 1987 on a tiny island in the Pacific, supporting the Johnston Atoll Chemical Agent Disposal System. We later provided similar services to facilities in Umatilla, Ore.; Pine Bluff, Ark.; and Newport, Ind. In total, SwRI helped in the destruction of more than 10,841 tons of chemical agents, 34 percent of U.S. stockpiles. ❖

D019277_4820

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

We developed a novel technique for identifying biomarkers of prenatal and infant exposure to drugs and other chemicals by analyzing baby teeth. Scientists are looking for possible evidence that chemical exposure could be associated with the rising incidence of autism (environmentalchemistry.swri.org).

Consolidated Financial Statements

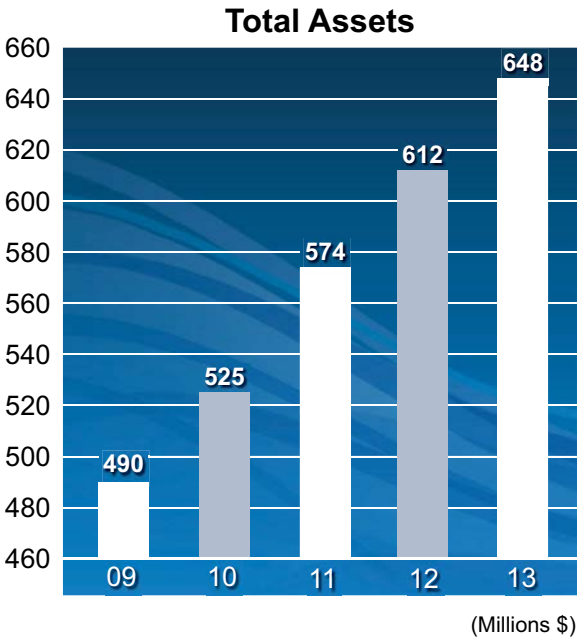
For the years ended September 27, 2013, and September 28, 2012

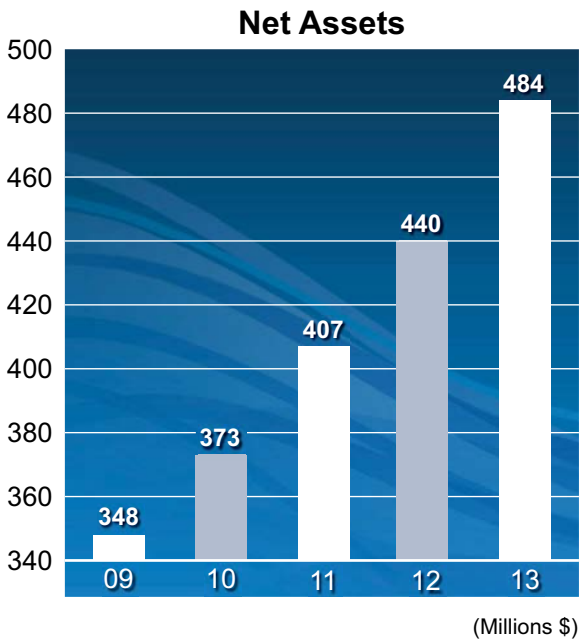
Income Statements (in thousands of dollars)

	2013	2012
Revenue	$591,730	$584,242
Direct Project Costs	346,181	346,703
Operating Income	245,549	237,539
Division Operating Expenses	133,871	130,481
General Overhead	59,489	54,632
Depreciation — General Facilities	15,666	15,343
Internal Research	6,769	7,426
Realized/Unrealized Gain on Postretirement Medical Funds	(5,793)	(6,641)
Income Before Federal Income Tax Expense	35,547	36,298
Federal Income Tax (Credit) Expense	(97)	326
Net Income	$35,644	$35,972

Balance Sheets (in thousands of dollars)

	2013	2012
Current Assets	$233,338	$239,712
Property and Equipment, Net	288,017	275,755
Other Assets	127,056	96,157
Total Assets	$648,411	$611,624
Current Liabilities	$97,823	$99,106
Noncurrent Liabilities	67,077	72,412
Net Assets	483,511	440,106
Total Liabilities and Net Assets	$648,411	$611,624





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