Southwest Research Institute®

Annual Report 2012

Sixty-Five Years

Southwest Research Institute®

65 years of 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 (shown on cover) and provides more than 2 million square feet of laboratories, test facilities, workshops and offices. Along with more than a dozen business and technical support offices located worldwide, SwRI's research program has expanded to include materials research, space science, emissions research, field services for the oil and gas industry, microencapsulation, and much more.

Southwest Research Institute, 1949

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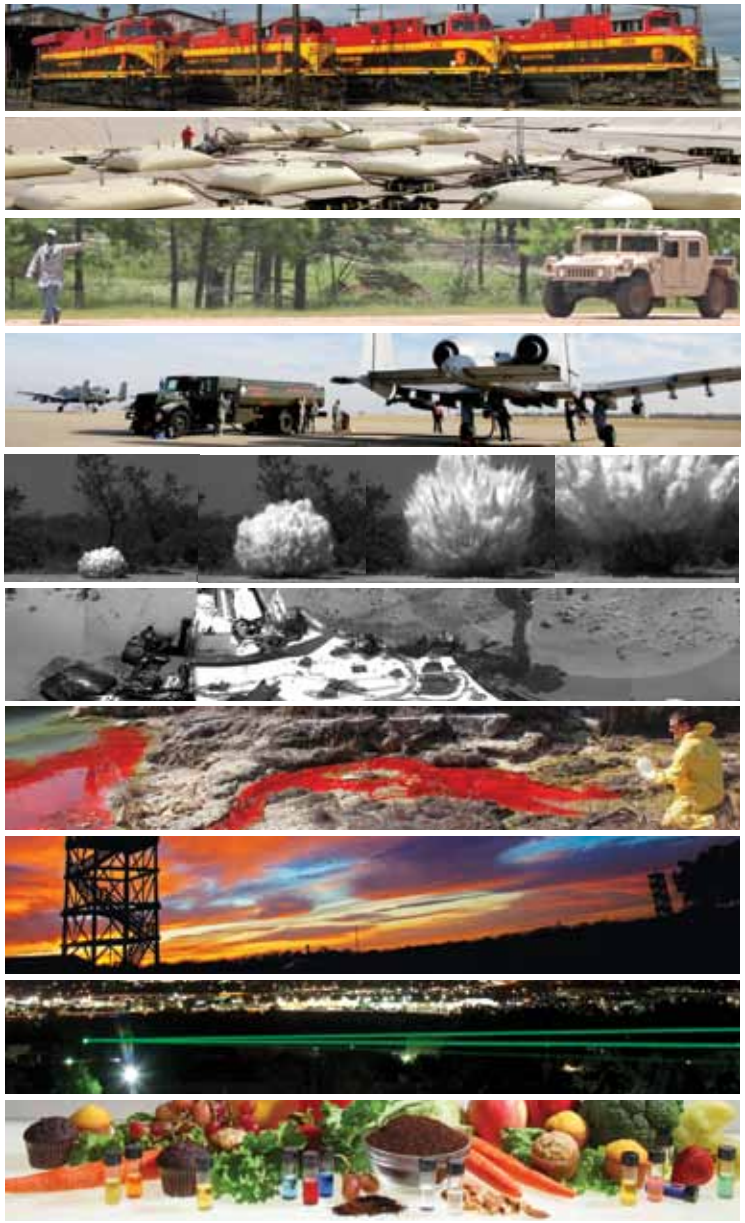


Message from the President

For the past 65 years Southwest Research Institute has pursued its mission to advance science and technology. The Institute's multidivisional approach to solving problems has helped both government and industry clients find answers to some of their most crucial challenges. This past fiscal year was no exception. We again logged record revenues reflecting thousands of ongoing programs. I am pleased to submit this annual report detailing just a few of the numerous accomplishments our staff achieved throughout the past year.

The Institute is poised for substantial growth in conventional and nonconventional energy-related research. Renewed technology development and equipment qualification for deep-water operations are thriving with the reopening of deep well drilling in the Gulf of Mexico. Complex technical issues associated with expansion of oil shale production and related environmental issues are providing new opportunities for research. The growing market for more efficient batteries will stimulate new development and rigorous technical evaluation. Expanded use of alternative and green fuels by the military will continue to require development and evaluation of new fuels and systems.

Our unmanned systems program is reaching new levels of technical and practical innovation. Using a modified military tactical vehicle, such as a Humvee, we showed our unmanned systems capabilities at the Fort Benning Robotics Rodeo. We demonstrated a vision-based system for autonomous navigation in harsh off-road environments and successfully showed soldiers using hand gestures interacting with a driverless vehicle.

We entered a new frontier in our space program with the Cyclone Global Navigation Satellite System, which establishes our ability to develop constellations of small spacecraft for specialized space applications. The Radiation Assessment Detector onboard the Mars rover Curiosity is traversing the Red Planet's landscape, measuring atmospheric radiation levels that could help scientists assess the planet's past and current potential to host life, as well as the radiation hazard for future manned missions to Mars.

Although funding has ended for the Yucca Mountain Nuclear Waste Repository, the Institute continues to support the Nuclear Regulatory Commission through the only Federally Funded Research and Development Center in Texas. Several long-term programs at chemical agent disposal facilities were successfully completed.

From peer-reviewed papers to presentations at technology-specific conferences, our staff members continue to receive significant recognition for their professional achievements. These activities document their influential participation in advancing science and technology. We collected our 37th R&D 100 Award from *R&D Magazine* for a novel hybrid casting technique for automotive engine manufacturing. The Institute has achieved a "superior" rating on the Defense Security Service vulnerability assessment for the second year in a row, a distinction earned by only a small percentage of government contractors. Further information about additional staff accomplishments can be found in the Highlights section of this report.

> ***"We again logged record revenues reflecting thousands of ongoing programs."***

In 2012 we managed more than 84 internal research and development projects, with expenditures of more than $7.4 million, to advance the Institute's technology base. This vital technical component provides Institute engineers and scientists the freedom to explore innovative concepts, many of which are described throughout this report.

Our comprehensive capital improvement program includes infrastructure projects to expand facilities for current and potential client bases. We completed expansions to facilities that add capacity to high-pressure testing chambers and dynamometers. We also expanded and centralized work to support a U.S. Army project to develop a new architecture to revolutionize and streamline tactical systems used in military vehicles. To improve employee health and wellness and to enhance our employee recruiting efforts, we completed the 25,000-square-foot SwRI Fitness Center, which includes a gym for basketball and volleyball, a weight room and exercise machines.

Staff members continue to be active participants in their community through volunteer efforts and donations to community organizations. The Institute's 2012 United Way campaign generated more than $760,000 in pledges.

For the past 65 years the Institute has diligently worked to expand our technical strengths and resources to meet strategic and fiscal goals. Our technical program in 2012 generated revenues of $584 million, compared to last year's $581 million, with net income of about $36 million. Total payroll to our employees was more than $240 million. A robust backlog of contracts and proposals is an encouraging sign for a successful year in 2013.

Even as we face new challenges in the coming year, we see new opportunities to expand our science and technology base. The support and commitment of our staff, Advisory Trustees and Board of Directors assure that our clients will continue to receive quality technical services and research in 2013 and beyond.

Respectfully submitted,

J. Dan Bates, President

Highlights

For the first time, Southwest Research Institute will build actual spacecraft — eight of them — for NASA's **Cyclone Global Navigation Satellite System**. We are expanding our space science and spaceflight instrumentation expertise to lead the development and integration of this constellation of microsatellates, expected to launch in late 2016. The CYGNSS mission aims to improve extreme weather event forecasting. Also for NASA, SwRI leads development of the **Magnetospheric Multiscale** instrument suite and is providing the Hot Plasma Composition Analyzers and central instrument data processors for the four satellites, which will deploy from a single launch vehicle in 2014.

This year we launched **ROS-Industrial™**, an open-source initiative that enables advanced industrial robotics applications by leveraging the ROS software enterprise. ROS, an open-source software project, provides libraries and tools to help software developers create **robot applications**.

For the automotive industry, staff members kicked off the **Particle Sensor Performance and Durability** consortium to characterize how particle sensors perform in engine exhaust applications under different operating conditions. Another effort, the **Energy Storage Technology Center**, applies multidisciplinary technologies to target energy storage uses, such as battery electric and plug-in vehicles, stationary utility grid storage and military electronic systems.

The U.S. Nuclear Regulatory Commission renewed its contract with SwRI to continue operating the **Center for Nuclear Waste Regulatory Analyses**, which provides independent technical assessment to the NRC. SwRI has operated the Center since 1987.

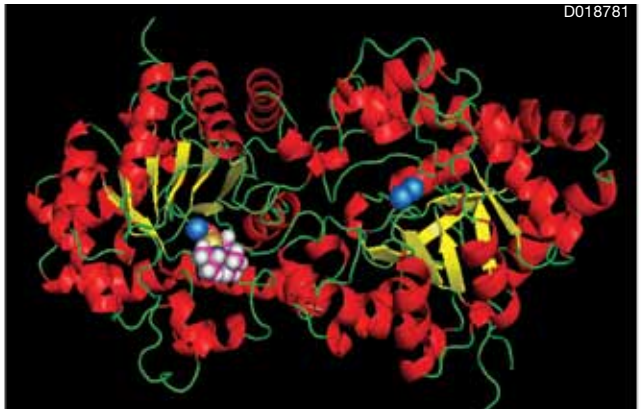
A titanium pressure sphere designed and fabricated at SwRI for the diving hull of the **Alvin deep ocean research submersible** was pressure certified this year. The new hull will allow Alvin to reach 99 percent of the ocean floor.

Several of our researchers received **national recognition** for professional accomplishments. Dr. William Bottke received the Farinella Prize for his research on the dynamics of asteroids and their association with meteorites, and Dr. Robin Canup was elected a member of the National Academy of Sciences. Staff members honored as Fellows include Dr. Ron Green, named a Fellow of the Geological Society of America, and Dr. William Ward, named a Fellow of the American Academy of Arts and Sciences.

The **SwRI staff** numbered 2,973 employees. Of those, 303 hold doctorates, 537 hold master's degrees and 764 hold bachelor's degrees. The Institute received 40 U.S. patent awards, filed 45 patent applications and submitted 53 invention disclosures. The technical staff published 533 papers and gave 521 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.



Under our internal research program, SwRI researchers are evaluating several proteins to aid in the treatment of nerve agent exposure. This three-dimensional structure shows the nerve agent VX bound to organophosphorus hydrolase (OPH), a bioscavenger protein that neutralizes nerve agents.

In 2012, SwRI initiated 84 new projects and spent more than $7.4 million on internal research. Some of this year's projects include:

extreme ultraviolet imaging and calibration • predicting vortex-shedding-induced pulsation amplitudes in piping systems • wet gas compressor performance using gas ejection • chlorine dioxide light-activated releasing additives • applied dermal delivery nano-formulations • traffic signal interface concepts • low resource mass analyzer • conformal and beamformed antenna array for airborne DF applications • diesel cold-start emission control for 2015–2025 LEV III emissions • robotic part handling for unstructured industrial applications • next-generation neutral atom imaging instruments for space research • magnetostrictive sensor probe for guided-wave testing of pipelines • piston temperature telemetry measurement on a turbocharged, direct-injection SI engine • general artificial-intelligence framework for robotic control • low-current detection system for a miniaturized solar wind plasma instrument • reconfiguration of radio frequency characteristics • guided-wave imaging technology • laser and medicated scar therapies • lithium ion battery capacity, cycle life and safety • detection of malware on vehicular networks • soil-structure interaction assessment of new modular reactors • uncertainty propagation in CFD-based fire probabilistic risk assessment • tsunami hazard assessment at nuclear installations • high-torque, hydraulic wind-up mechanism for four-square gearbox test stand • advanced situational awareness demonstration system • next-generation neutrally buoyant sensors • lubricant effects on end-gas knock in high-performance engines • analytical modeling of metamaterials • prevention of ice build-up on power line conductors and ground wires • traffic management center video distribution system • mass spectrometry of cave atmospheres • regolith properties of asteroid surfaces • high-rate heterogeneous deformation measurement experiment • secure mobile applications for corporate travelers • GPS-denied localization system • novel scaffolds for tendon/ligament regeneration and tissue engineering

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*

Stringent emissions and fuel economy standards are driving progress in the automotive industry, and Southwest Research Institute is developing the technologies to meet today's increasingly tougher demands. As a leader in fuels and lubricants, emissions reduction, and fuel economy technologies, we understand these interrelated fields and use that knowledge to develop, improve, evaluate and verify products for land, rail and water transport vehicles, as well as for stationary power equipment.

The staff addresses an array of diverse emissions challenges to meet government mandates, developing new engine designs (enginedesign.swri.org) and evaluating exhaust aftertreatment systems (emissionsresearch.swri.org).

Our engineers continue to advance air, exhaust gas recirculation and fuel control technologies. We recently applied these technologies to a prototype diesel vehicle that meets 2014 Euro VI oxides of nitrogen emissions standards, without NO_x aftertreatment (engineresearch.swri.org).

With the Environmental Protection Agency, our staff is developing a reference grade particle generator to measure and understand particle nucleation and growth phenomena. This research could help define new emissions regulations for nanoparticles using particle number instead of the commonly used particle mass.

SwRI provided detailed engine emissions data to multiple renewable fuel developers to help obtain EPA registration for their products. We measured criteria pollutants, air toxic emissions, hydrocarbon speciation and polyaromatic hydrocarbons in the exhaust. This support helps fuel and fuel additive producers analyze the combustion and evaporative emissions generated from on-highway motor vehicles. These data allow the EPA to evaluate fuels and fuel additives for toxic and health effects, and registration allows the suppliers to sell their products for on-road use, paving the way for renewable and sustainable fuels that produce cleaner emissions.

We recently developed a real-time instrument, RT-Ash™, to measure ash from engine exhaust. The system allows us to quantify metallic ash emissions and oil consumption from vehicles in real time.

For two projects funded in part by the California Air Resources Board, we

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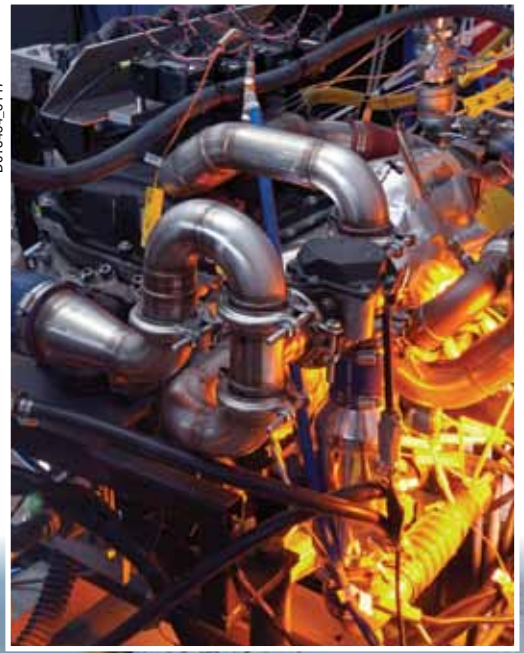

SwRI's HEDGE® consortium is developing the next major advancement in gasoline engine technology.

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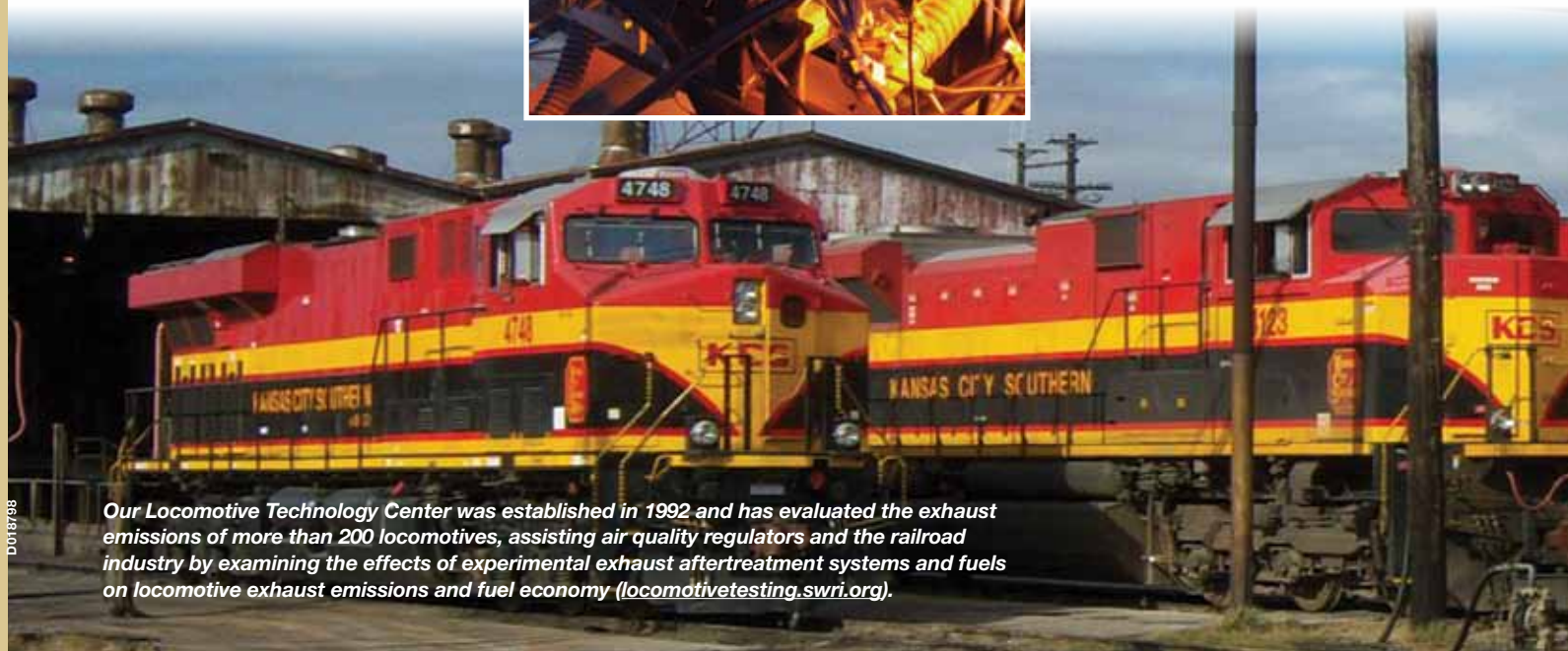

Our Locomotive Technology Center was established in 1992 and has evaluated the exhaust emissions of more than 200 locomotives, assisting air quality regulators and the railroad industry by examining the effects of experimental exhaust aftertreatment systems and fuels on locomotive exhaust emissions and fuel economy (locomotivetesting.swri.org).

are retrofitting diesel particulate filters onto 2,100 horsepower switching locomotives operating in urban areas of California (gasengines.swri.org). These relatively new "GenSet" locomotives use three 700 hp EPA Tier 3 non-road diesel engines instead of the traditional switcher locomotive configuration of a single 2,100 hp EMD engine. Using this system, one engine runs most of the time, with the other two engines coming online only when needed for additional power. After baseline testing, the DPFs were installed and exhaust emissions were tested to verify particulate matter emissions were reduced. SwRI data loggers remotely monitored performance and the locomotives returned to SwRI after 1,500 and 3,000 hours of operation to verify DPF performance over time.

As the U.S. Tier 4 emissions standards are phased in, engine manufacturers are bringing new, emissions-compliant engine and aftertreatment systems to market. To certify these systems, manufacturers must show the emissions regulations can be met for the "full useful life" of the system's application — up to 22,000 hours of operation, in some cases. SwRI provides operations around the clock to support this effort.

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Under our Pre-Ignition Prevention Program, we developed a data acquisition system that allows engineers to continuously store combustion data to analyze abnormal events such as knock and low-speed pre-ignition, which can severely damage engines.

We also support the automotive industry by leading precompetitive consortia for manufacturers and suppliers to advance new technologies at a low cost. Since its inception, the largest gasoline engine research consortium in the industry, HEDGE®, now numbering 28 members, has developed many promising technologies, including a dedicated-EGR (exhaust gas recirculation) engine (hedge.swri.org). The design uses one or more cylinders of a multi-cylinder engine to reform gasoline into syngas and recycle it to the engine. The next phase of the consortium kicks off in 2013, with a focus on producing spark-ignited engines that surpass the efficiency of diesel engines, with lower emissions and cost.

We also launched a new consortium targeting particle sensor performance and durability to improve fundamental understanding of onboard diagnostics particle sensors, which are expected to be installed on vehicles in the near future (pspd.swri.org).

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SwRI's tribology laboratory supports client programs with a variety of instruments to study the interactions between automotive lubricants and components, including temperature, friction, wear and surface effects (tribology.swri.org).

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***

Other ongoing consortia are developing high-efficiency diesel engines (chede.swri.org) and advancing energy storage and safety (esses.swri.org).

SwRI has tested and characterized more than 20 heavy-duty diesel engines over the past decade as part of a subscription benchmarking program (benchmarking.swri.org). Staff members evaluate engine design, performance, fuel economy and emissions behavior. In addition, with natural gas becoming a more viable fuel option, natural gas engines were recently admitted to the program.

Government mandates for increased fuel economy, combined with rising fuel costs, have stimulated the demand for more efficient fuels and lubricants. Our services to the automotive industry help manufacturers and suppliers meet regulatory and competitive goals.

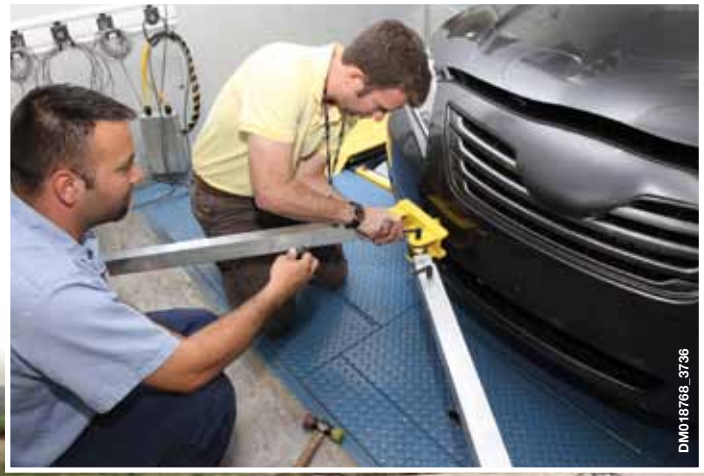
As the industry moves to lower-viscosity engine oils to improve fuel economy, manufacturers are evaluating the impact of these thinner lubricants on engine wear and life. Our new tribology laboratory houses an array of tribometers, rheology equipment, engine component rigs and fired research engines to support manufacturers with engine screener tests and related lubricant research and development (tribology.swri.org).

New engine oil requirements for light-duty passenger cars and on-highway, heavy-duty diesel trucks are projected for 2015. We are establishing three new engine-dynamometer test methods for heavy-duty diesel trucks and six new tests for light-duty passenger cars. The tests will address a range of issues related to engine hardware durability, emissions system protection, oil thickening, oil deposits and thinner engine oils used to improve fuel economy.

To support the development of these new tests, as well as to keep current tests viable for several more years, we are expanding our heavy-duty diesel engine dynamometer testing laboratory to include eight new test cells. A new exhaust system will capture the particulate matter produced by these engines.

In addition, we recently began replacing fuel-powered test stands with electric-powered stands to reduce on-site emissions and provide greater reliability and simplicity.

Our test cells assess minute differences in torque levels to measure the effects of lubricants on engine



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We upgraded our chassis dynamometer facilities with a rigid restraint system to improve the repeatability of fuel economy measurements, allowing us to help clients develop the next generation of fuels and lubricants.

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Staff members recently designed and built a new facility to test collapsible fuel bladders used by the military.

friction. We recently upgraded our chassis dynamometer facilities with a rigid restraint system to improve the repeatability of fuel economy measurements to better help our clients develop the next generation of fuels and lubricants (ldemissions.swri.org).

The U.S. Army TARDEC Fuels and Lubricants Research Facility at SwRI celebrated its 55th anniversary this year (tardec.swri.org). This government-owned laboratory provides dedicated service to the Army fuels and lubricants technical program, as well as evaluates and develops alternative fuels that may lead to energy independence (altfuels.swri.org).

This year, a new facility will provide testing capability to U.S. military product regulations using fuel rather than water — the first facility in the nation available to do so — in accordance with environmentally safe guidelines. This facility will be available to perform R&D and first-article testing of collapsible fuel bladders, as well as other tactical petroleum handling equipment for TARDEC and all other military services.

Manufacturers increasingly are implementing downsized, turbocharged engines to improve vehicle efficiency. One of the challenges brought about by these smaller engines is uncontrolled ignition, which leads to damaging engine knock. We initiated a consortium called the Pre-Ignition Prevention Program, now with 22 members, to study the fundamental processes that cause this phenomenon to help the engine and oil industries develop solutions to the problem (p3.swri.org).

This year we launched an Energy Storage Technology Center, a collaborative effort to develop new energy storage systems. The center applies SwRI's multidisciplinary expertise to targeted energy storage uses, such as battery electric and plug-in vehicles, stationary utility grid storage and military electronic systems. ❖

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.

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The hybrid ceramic-sand core casting technology combines aerospace ceramic and automotive casting processes to precisely and cost-effectively manufacture engine components. SwRI and Grainger & Worrall Ltd. of the United Kingdom earned a 2012 R&D 100 Award for this development.

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SwRI completed installation of four mileage accumulation dynamometers enhanced with temperature- and humidity-controlled inlet air systems that allow for consistent engine operating conditions regardless of ambient conditions. One of the dynamometers has four-wheel-drive capability (shown), which is necessary to test all-wheel-drive vehicles and hybrids.

Automation and Data Systems

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

Southwest Research Institute specializes in integrating the latest technology into novel systems to create next-generation advances in applications ranging from factory automation to smart energy, intelligent transportation and advanced military ground vehicles.

SwRI is developing a fully autonomous tactical unmanned ground vehicle as part of the Small Unit Mobility Enhancement Technology program. SUMET is an open, modular and scalable hardware and software architecture to meet emerging Navy and Marine Corps UGV requirements by taking soldiers out of harm's way when logistically possible. SwRI engineers are collaborating with the U.S. Army to implement Dismounted Solider Autonomy Tools onto highly mobile all-terrain vehicle platforms by integrating SUMET technology with Army equipment (ivs.swri.org).

For intelligent vehicle applications, we are developing cooperative vehicle systems to detect vulnerable road users — pedestrians, bicyclists and motorcyclists — around large commercial trucks. We also are developing algorithms to allow a vehicle to autonomously navigate a busy intersection where multiple vehicles and pedestrians are present (ivs.swri.org).

In association with two large statewide intelligent transportation systems projects in Texas and Florida, we completed ITS software to support adding dynamic lanes — lanes that reverse directions based on traffic conditions — and many other enhancements (its.swri.org).

SwRI is the technical lead of the Army's VICTORY project, an architecture- and standards-based initiative aimed at providing interoperability between electronic systems on Army ground vehicles. Using the VICTORY data bus as a platform, SwRI is developing advanced situational awareness technologies to provide trustworthy and actionable information to soldiers (tacticalnetworks.swri.org).

In 2012, we applied our expertise in embedded systems security to new areas. In addition to our work in smart grid security, we are now helping to secure embedded devices in other domains, including the oil and gas, railroad and medical device industries. Using internal funding, we are developing technology to detect the presence of malware in vehicles (embeddedsecurity.swri.org).

Under the Smart Power Infrastructure Demonstration for Energy Reliability and Security (SPIDERS) program, SwRI analysts are integrating electric vehicles as energy

Using ROS-Industrial software, we have demonstrated capabilities not available in industrial robot control, such as material handling in dynamic environments with on-the-fly object segmentation, grasp planning and collision avoidance (rosindustrial.swri.org).

SwRI successfully demonstrated new unmanned and cooperative vehicle technologies at the 2012 Robotics Rodeo. For a commercial client, we demonstrated interaction with dismounted "soldiers" using arm signals to control the "follow-me" aspect of this SwRI fully autonomous vehicle (ivs.swri.org).

storage devices into a Fort Carson Army Base smart grid to demonstrate self-contained energy sustainability during electrical grid disruptions (smartenergygrid.swri.org).

Analysts are also helping the Department of Veterans Affairs revamp medical systems software, modernizing the VA's legacy pharmacy system (intelligentsystems.swri.org).

In 2012, SwRI launched the ROS-Industrial open-source initiative to enable advanced industrial robotics applications by leveraging the ROS software enterprise. ROS is an open-source software project initiated by Willow Garage, which provides libraries and tools to help software developers create robot applications primarily for research and personal robots. ROS-I focuses on enabling industrial software developers to build more capable robot applications quickly and easily using a common platform (rosindustrial.swri.org).

For more than 17 years, SwRI has operated a Texas Manufacturing Assistance Center to help local manufacturers with process improvement and production efficiency as well as developing new products, markets and business practices. We work with technology incubators to help solve technical challenges for their member companies; for example, helping a start-up verify a system to purify contaminated wastewater produced by hydraulic fracturing oil production techniques (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.

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Today's industrial robots serve a broad range of small- and medium-scale applications; however, scaling up these systems has often proven cost-prohibitive. To expand robotics for new large-scale applications, SwRI developed and demonstrated a Metrology Referenced Roving Accurate Manipulator (MR ROAM) integrating an off-the-shelf manipulator, mobile platform and metrology system to operate accurately in a large work space (mobilemanipulator.swri.org).

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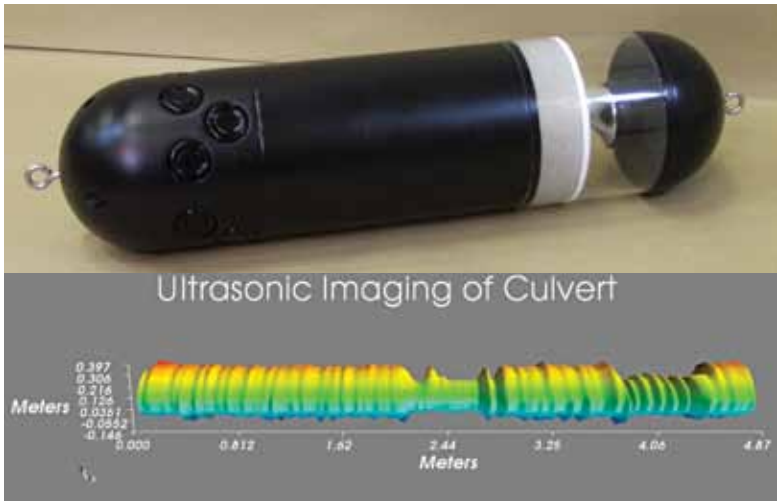

Our engineers have developed a self-contained culvert inspection system that combines our R&D 100 award-winning Neutrally Buoyant Sensor ultrasonic mapping system with a 360-degree camera to provide 3-D representations and live video of culverts, conduits and other structures. SwRI is exploring the use of similar mapping technologies in other potentially hazardous environments, including nuclear power plants, sewer systems, caves and aquifers (sensornetworks.swri.org).

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)*

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

Specifically, our engineers have played a critical role in a long-term program to revamp the A-10 Thunderbolt into a multifunctional digital weapons system. In 2012, SwRI engineers fielded the Suite 7B Operational Flight Program for the Improved Electronic Processor Unit, which monitors the engine and structural components, allowing condition-based maintenance on individual aircraft based on flight data and pilot handling. This cost-effective scheduled maintenance makes the A-10 the most combat-ready fleet in the Air Force (aircraftsystems.swri.org).

To increase throughput and lower maintenance costs at the world's largest helicopter repair facility, SwRI is managing and implementing equipment design and installation for a new 112,000-square-foot Dynamic Component Rebuild Facility at the 50-year-old Corpus Christi Army Depot. The facility will feature the latest technology in testing and manufacturing to better support the warfighter. One of the new technologies that SwRI is developing for CCAD is a groundbreaking high-speed direct-drive load system to evaluate rebuilt helicopter engines before they are put back into service. These turbo shaft test cells will require significantly less maintenance and downtime than the existing equipment, and the energy they absorb produces electricity, which could offset energy costs (aerospaceservices.swri.org).

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SwRI designed and developed a sugar cane harvester simulator, including hardware and software, to model machine dynamics and performance and to support rich displays that show the effects on the crop. We generated training lessons that include real-time feedback and detailed scoring reports, allowing trainees to learn from their successes and mistakes (learningsystems.swri.org).

For the past 10 years, SwRI has managed hardware and software enhancements to flight-line support equipment, troubleshooting cockpit situational awareness displays that show important theater data, such as identifying friends and foes, and allow secure communications via the same display. The Situational Awareness Data Link integrates close air support aircraft with the digitized battlefield to shorten response time for ground force support. This technology also benefits the National Guard's C-130 fleet (avionics.swri.org).

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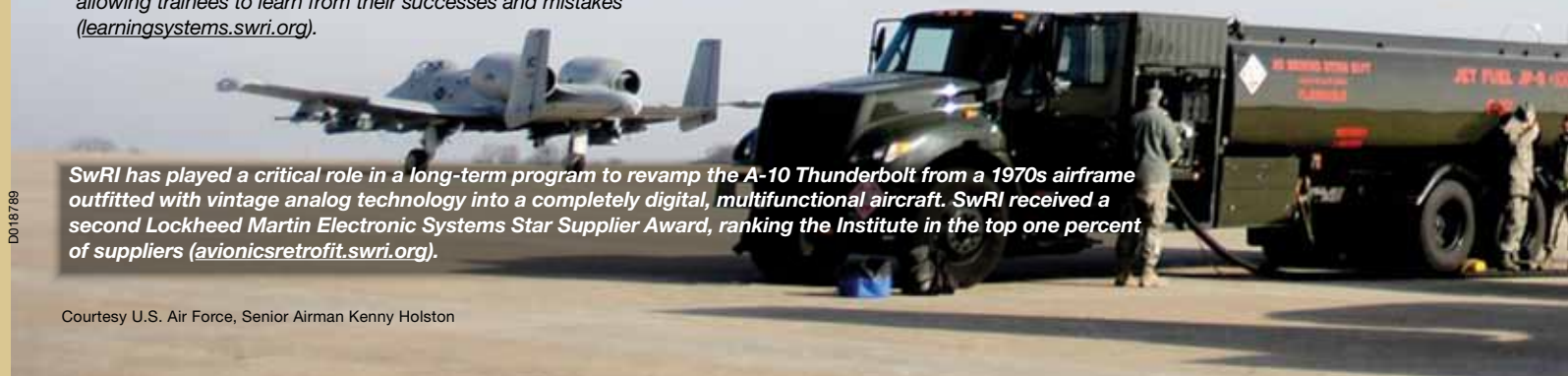

SwRI has played a critical role in a long-term program to revamp the A-10 Thunderbolt from a 1970s airframe outfitted with vintage analog technology into a completely digital, multifunctional aircraft. SwRI received a second Lockheed Martin Electronic Systems Star Supplier Award, ranking the Institute in the top one percent of suppliers (avionicsretrofit.swri.org).

D0187789

Courtesy U.S. Air Force, Senior Airman Kenny Holston

The SwRI Warner Robins office continues to support Air Force electronic warfare systems, providing software maintenance, verification and validation, continuously updating and upgrading the EW pods used to detect and defeat evolving enemy threats (ew.swri.org). SwRI developed hydraulic test stands to conduct performance tests of hydraulic fluids used on the B-52 power drive. These test stands simulate operational pump and subassembly loads and monitor flow rates, input power, pressures, temperatures, and control valve positions to characterize system efficiencies.

Since 1998, SwRI has supported the USAF Joint Reliability Availability Management System, a data analysis and reporting system used by more than 400 government and contractor personnel daily. To maximize aircraft availability and mission effectiveness, JRAMS provides web-centric tools for in-depth analysis of aircraft maintenance, supply and operations information for a wide range of USAF weapon systems.

During 2012, SwRI developed a personal computer-based simulator to train sugar cane harvester operators. This simulator allows operators to learn and practice driving and operating a harvester under various conditions in a risk-free, simulated environment. Operators practice safe and efficient techniques for harvesting and learn how to set up and adjust the harvester in the field to maximize crop yield and quality, while minimizing potential damage to the harvester and the field (learningsystems.swri.org).

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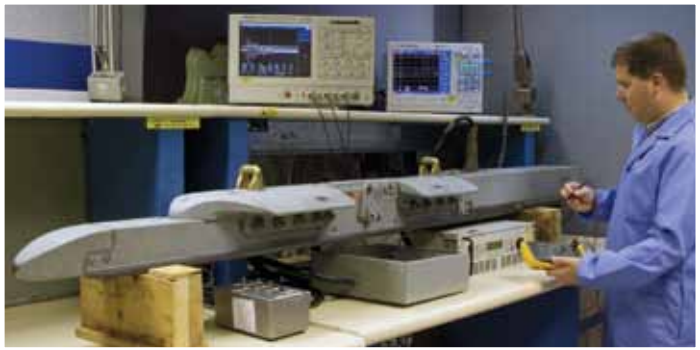


Recently, SwRI identified the root cause of a fleet-wide A-10C weapon system error associated with the Maverick missiles. The cockpit weapon status display would erroneously indicate the system was in a mode that blocked deployment against enemy targets. SwRI identified the root cause of the anomaly, and the Air Force is flight testing a solution we developed to resolve the issue (aircraftsystems.swri.org).

An SwRI-led team is creating cunning cyber security technology for the Defense Advanced Research Projects Agency (DARPA). While it will not replace password protection, this novel software-based authentication tool, called covert-conditioned biometrics, employs a unique sequence of problem-solving moves to distinguish between a legitimate user and an imposter. SwRI analysts incorporate principles of adaptive learning, behavior modification and game theory to capture and discriminate the "cognitive fingerprint" that authenticates a user's identity. ❖

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

D018765_2517

SwRI engineers are developing mechanical structures and test cell infrastructure for a novel electric dynamometer system that will be installed at the revamped Corpus Christi Army Depot helicopter maintenance facility. This first-of-its-kind, direct-drive dynamometer is able to evaluate rebuilt T700 turbine engines under dynamic load without the use of intermediate gear boxes.

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*

Southwest Research Institute's mechanical engineers continue to support energy, infrastructure and defense research, applying expertise in fluids and flow, structural engineering, materials science, engineering dynamics, sensor systems and nondestructive engineering. Core programs include oil and gas production and transmission, alternative energy and military ground vehicle armament. We also help our clients extend the life and improve the safety, reliability and efficiency of aging systems ranging from military aircraft to petroleum pipelines.

Emerging energy policies focus on developing cleaner alternative energy technologies, while improving the processes associated with mainstream energy sources, including fossil fuel production, transport and emissions. In 2012, we were awarded a number of significant new projects from the Department of Energy to develop advanced clean coal and solar energy technologies (machinery.swri.org).

Meanwhile, the offshore petroleum production industry is emerging from a transition period since the Deepwater Horizon oil spill, with increased oil prices and safety concerns fueling SwRI test and development work for this important resource. New pressure chambers designed to simulate harsh underwater conditions were installed in 2012, expanding our capabilities and capacities. A new blast-resistant test cell accommodates high-pressure, high-temperature assessments of safety equipment, including the ability to conduct fugitive emissions and leak testing (deepoceansimulation.swri.org).

Continuing more than 60 years of service to the oil and gas transmission industry, SwRI has developed a sampling device to measure the fraction of liquid droplets carried in the gas phase of high-pressure wet gas and multiphase flows. With this device, SwRI is providing clients more information about flow conditions and improving models of wet gas streams in piping (fluids.swri.org).

Expanded materials engineering laboratories are supporting a range of activities, from evaluating and creating more durable

D018353_5587

Using internal research funds, SwRI has developed EDAS®-MS, a new generation of ultrasonic test instrumentation designed for high-speed inspection of nuclear reactor pressure vessels and piping. The new data acquisition boards shown reduce the total system weight and volume by more than half, while maintaining compatibility with prior versions (ndesensors.swri.org).

D018690_3000

Our long-term program studying the structural integrity of the U.S. Air Force T-38 training jet continues with side-by-side full-scale wing testing to better understand flight stress under variable conditions. This fatigue test program will enable the Air Force to operate this 50-year-old aircraft to train fighter pilots well into the future (aerospacestructures.swri.org).

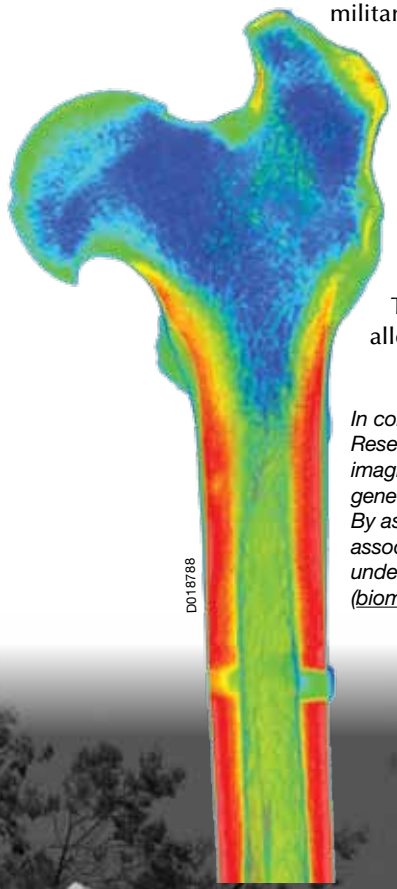
To investigate techniques to neutralize buried improvised explosive devices, SwRI characterized a standard, high-order detonation of an ammonia nitrate fuel oil IED at our remote test site (engineeringdynamics.swri.org).

D018783

D018784

materials and components to assessing complex mechanisms associated with bone fractures (biomechanics.swri.org). SwRI develops unique surface treatment technologies to apply corrosion-resistant alloy, diamond-like and nanocomposite coatings onto complex, industrially relevant geometries. SwRI scientists also are designing and developing methods of synthesis for advanced materials including metamaterials, graphene and clathrates for future energy and defense needs. These new developments provide clients with equipment that can withstand the evolving and increasingly demanding environments encountered in the oil and gas, power generation and military arenas (surfaceengineering.swri.org).

On the opposite end of the life spectrum, we are continuing work with aging military systems, assessing the structural integrity of the T-38 airframe to allow the Air Force to safely use the vintage trainer decades past its original design life (aerospacestructures.swri.org). Our structures specialists also pressure-certified and delivered the titanium pressure sphere for the upgraded diving hull of the Alvin deep ocean research submersible. The new hull, designed and fabricated by SwRI, will allow Alvin to reach 99 percent of the ocean floor.



D018788

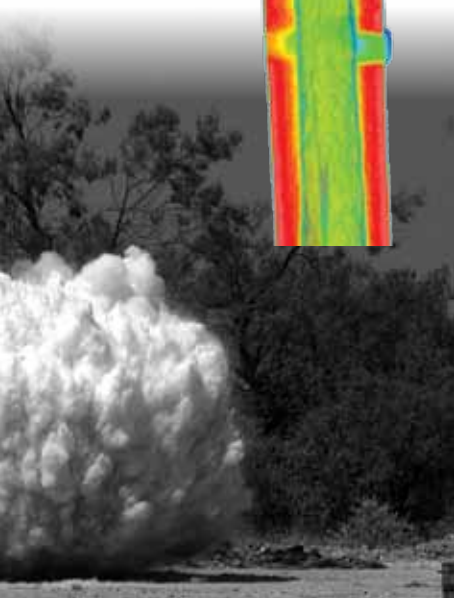
In collaboration with scientists at the Texas Biomedical Research Institute, SwRI staff members are using new microCT imaging capabilities to study how material, mechanical and genetic contributions affect the structural integrity of bones. By assessing complex mechanobiological mechanisms associated with bone fracture resistance, scientists can better understand genetic variations associated with fractures and disease (biomechanics.swri.org).

We continue developing nondestructive evaluation technologies, such as our magnetostrictive sensor systems (ndesensors.swri.org), to evaluate the service life of infrastructure ranging from pipes to nuclear power plants. SwRI added new offsite facilities to expand our capabilities in engineering dynamics, particularly in evaluating materials and components for their resistance to landmines and hypervelocity impacts (engineeringdynamics.swri.org). ❖

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

D018703_4181

Centrifugal compressors are critical components for gas handling and production, and high-performance designs require experimental testing. Leveraging direct metal laser sintering technology to rapidly manufacture prototypes, SwRI engineers developed a novel single-stage, open-loop compressor test rig to measure the performance of centrifugal impeller designs. Operating at speeds up to 39,000 rpm, the rig test offers shorter test cycle times than other single-stage rigs and cost savings an order of magnitude less than conventional closed-loop testing (machinery.swri.org).



D018785

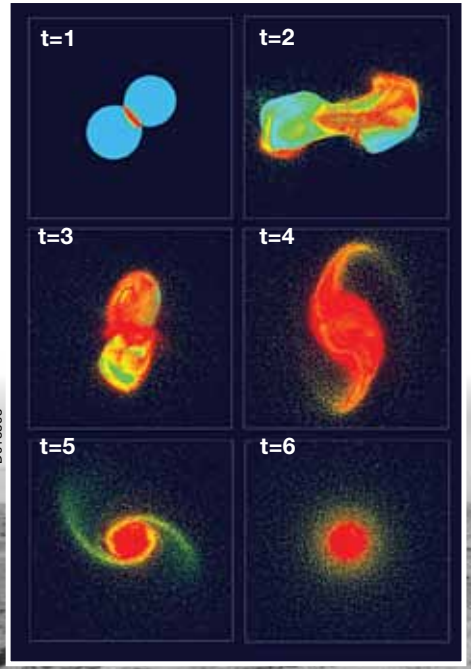
D018786

Space Science and Engineering

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

Southwest Research Institute is an internationally recognized center for basic space science research and for the development of spacecraft instrumentation and avionics systems and has recently expanded its space-related activities into the area of microsatellite design, development and fabrication.

Building on its heritage of spacecraft avionics and subsystem design and development, SwRI is developing eight microsatellites under contract to the University of Michigan for the Cyclone Global Navigation Satellite System, NASA's first spaceborne Earth Venture-class mission.



D018803

SwRI scientists use computer models to study the formation and evolution of planetary systems. A recent simulation of the formation of the Moon from debris produced by the impact of a Mars-sized protoplanet on the early Earth potentially explains the similarities in the isotopic composition of the Earth and Moon, answering a major objection to the giant impact theory.

The CYGNSS constellation measures Global Positioning System signals scattered from the ocean surface to determine near-surface wind speed with unprecedented spatial coverage and temporal resolution, providing researchers with an improved tool for investigating the genesis and intensification of tropical cyclones. In addition to building the eight spacecraft, SwRI is responsible for CYGNSS mission operations and overall project management.

Our research program in space physics and planetary science continues to yield results that deepen our knowledge and understanding of the solar system and its place within the galaxy. Analysis of data from the SwRI-led Interstellar Boundary Explorer has revealed that, contrary to most theoretical predictions, no bow shock exists in the flow of interstellar gas upstream of the heliosphere, the magnetic bubble within which the Sun and planets reside.

D018795

Courtesy Joe Mancewicz

This artist's rendering shows the deployment of the SwRI-built CYGNSS microsatellites from the constellation's deployment module. The eight two-foot-wide spacecraft are released with their solar array "wings" stowed; when fully deployed, the wings measure six feet across.

D018790

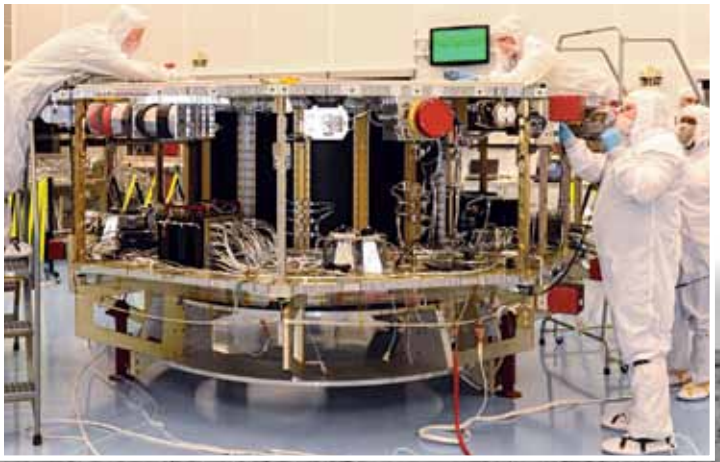
Courtesy NASA/JPL-CalTech

Working with advanced computer models, staff scientists have found new solutions to outstanding questions about the giant-impact theory of lunar formation and about the duration of the Late Heavy Bombardment, during which the early Earth and Moon were pummeled by impactors from a now largely extinct part of the asteroid belt. Other studies by SwRI researchers focus on identification of exoplanets, development of new computer models for probing planetary system formation and evolution, energetic neutral atom imaging of magnetospheric disturbances, and the properties and structure of the solar wind.

SwRI-developed instruments are flying on the European Space Agency's Rosetta comet mission and on two SwRI-led NASA planetary probes, the New Horizons Pluto mission and the Juno mission to Jupiter, as well as on NASA's Lunar Reconnaissance Orbiter. The SwRI-built Radiation Assessment Detector has been successfully measuring fluxes of solar energetic particles and galactic cosmic rays since the arrival of the Curiosity rover on Mars in August. We are currently building a second RAD for deployment on the International Space Station. Work on the Strofio instrument for ESA's BepiColombo mission to Mercury is complete, and fabrication of the four Hot Plasma Composition Analyzers for NASA's Magnetospheric Multiscale mission is nearing completion, with two instruments already delivered and integrated to the spacecraft.

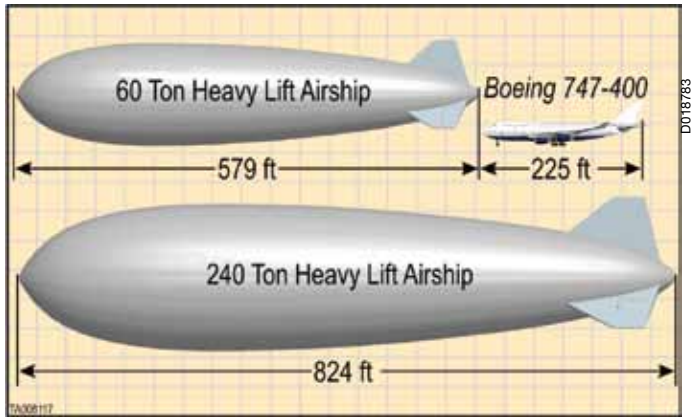
SwRI has experienced significant growth and expansion in the space electronics sector during 2012 (spaceavionics.swri.org). Key new technical areas include low-cost avionics that enable development of the CYGNSS spacecraft, next-generation instrument processing electronics and a new invention for buoyancy control of heavy-lift airships. We completed four engineering models of the communications systems for the Defense Advanced Research Projects Agency's System F6 "fractionated" spacecraft architecture program and have received approval to build a full flight system. Other projects include command and data handling electronics for one of the instruments on NASA's OSIRIS-REx asteroid sample return mission and an ultra-high-performance data handling system with a multi-gigabit-per-second data rate that provides two orders of magnitude improved performance and throughput over previous space systems. ❖

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



D018803

The Magnetospheric Multiscale mission comprises four spacecraft, with one shown here following integration of the instrument deck with the spacecraft bus at NASA's Goddard Space Flight Center. SwRI leads development of the MMS instrument suite and is providing the Hot Plasma Composition Analyzers (round red tag cover) as well as the central instrument data processors for the four spacecraft.



D018783

SwRI is a leader in airship technology and recently expanded its expertise into the development of enabling technologies for heavy-lift cargo airships. Staff members filed a patent disclosure for a method of producing electrical power and controlling the buoyancy of combustion-engine-powered airships. This technology will enable heavy-lift airships to carry up to 400,000 pounds of cargo economically at altitudes up to 10,000 feet.

Data obtained by the SwRI-built Radiation Assessment Detector (circled in red) on the Mars rover Curiosity will help NASA characterize the radiation environment that astronauts could encounter on future manned Mars missions.

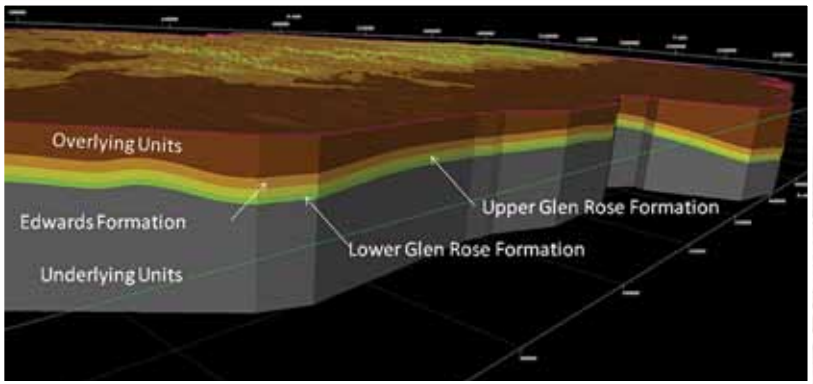
Geosciences and Engineering

- *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 analysis*
- *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*

For 25 years, Southwest Research Institute has been developing extensive geosciences and engineering capabilities that primarily address radioactive waste disposal. Recently, in order to maintain the Nuclear Regulatory Commission's Center for Nuclear Waste Regulatory Analyses expertise related to radioactive waste disposal and other aspects of the back end of the fuel cycle, 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 aspects of the entire nuclear cycle, from uranium mining to ultimate disposal of wastes; from licensing of enrichment facilities to nuclear power reactors; from radioactive waste reprocessing to facility decommissioning. In addition, we apply our field, laboratory and computational expertise to the broader energy industry, from petroleum exploration and production to supporting emerging green technologies, as well as to water resource and planetary science programs.

The NRC renewed its contract with SwRI for the fifth time to operate the CNWRA®. This contract assures needed technical assistance and research support to NRC activities related to storage, transportation, possible reprocessing and ultimate geological disposal of spent nuclear fuel and high-level radioactive wastes through September 2017 (cnwraweb.swri.org).

D018792



In 2012, we began a major three-year project with the Edwards Aquifer Authority to develop the next generation of groundwater computer modeling in south Texas. The enhanced model will include not only the recharge and confined zones, but also the contributing zone.

In 2012, work related to Center special competencies supported the NRC in evaluating 13 nuclear power plant license renewal requests, in addition to evaluating corrosion of nuclear power plant components and assessing the life-management programs for aging infrastructure. The staff also began evaluating nuclear power plant fire-protection programs that incorporate fire modeling to meet National Fire Protection Association standards. SwRI has reviewed and assessed the adequacy and applicability of fire models and conducted quality assurance reviews of new probabilistic fire-protection programs (environmentalimpact.swri.org).

D018707_4306

Using internal research funding, SwRI studied sea ice in the Southern Ocean surrounding the frozen continent of Antarctica. Studying satellite radar data to characterize changes in the volume of sea ice, scientists gained insight into seasonal changes and regional and global heat-energy balances.

For the joint industry Carbonate Fault Project, SwRI and the Edwards Aquifer Authority performed tracer tests at Canyon Lake Spillway Gorge to understand how fluid moves through faults and fractures. We introduced nontoxic dyes into the groundwater flow system and then monitored the timing and location of discharge from springs within the Glen Rose Formation.

D018348_5118

Following the Fukushima accident, the Center began working with the NRC to characterize risks associated with natural disasters, assessing seismic risks and flood hazards for U.S. nuclear power plants and supporting fuel cycle facilities.

We are exporting our expertise overseas, supporting nuclear waste disposal programs around the world. Our evaluations are helping Sweden assess a potential disposal site. We updated computational tools to evaluate reliability of surface storage of spent nuclear fuel and high-level radioactive waste and used them to analyze a planned facility in an Asian country. We will soon extend services in probabilistic risk assessment to other nuclear facilities.

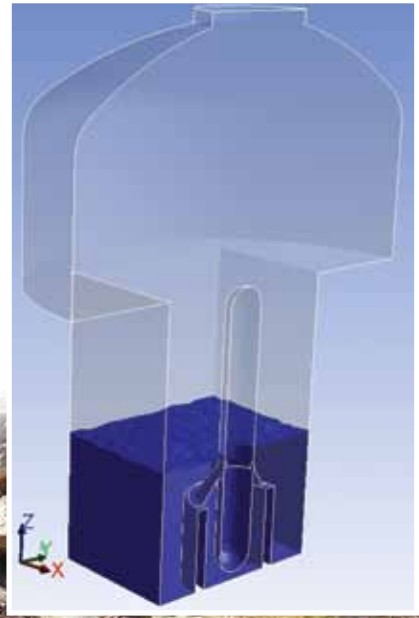
In 2012, SwRI created a new consortium to provide expert geological support to companies developing shale oil in South Texas and Canada. We expanded the range of our geologic training courses, locations, and topics and continue to market and improve our award-winning 3DStress® software. Scientists applied the software to numerical simulations of induced hydraulic fracture to produce unconventional petroleum reservoirs (3dstress.swri.org). We recently completed Phase II of the oil-industry funded Carbonate Fault Project, conducting field and laboratory investigations, and numerical modeling of the Hidden Valley Fault at Canyon Lake Gorge.

We continued our groundwater research, conducting several projects with underground water conservation districts throughout south central Texas. We expanded our expertise to surface water resources, simulating erosion of emergency spillways during extreme flooding (hydrology.swri.org).

We also apply our geosciences expertise to the extraterrestrial, conducting physical analog modeling of magma transport on Mars (analogmodel.swri.org). This laboratory study is assessing how the host rock is affected as lava punches through under high pressure. These experiments produced some particularly detailed structures of what magma looks like as it cools and hardens (planetary geosciences.swri.org). ❖

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

D018797



CNWRA scientists conducted internal research to examine the seismic response of a simplified buried small modular reactor. This work supports future NRC projects for small, self-contained nuclear power plants that industries and utilities are considering as a flexible, cost-effective energy alternative, particularly in remote locations.

D018796

SwRI performs geomechanical modeling to help clients improve safety, optimize production, decrease costs and reduce risks associated with hydraulic fracturing during petroleum production. This model shows a horizontal well in blue, intersected by natural fractures, shown as squares color-coded by how likely they are to slip. The circles indicate microseismic events (zero or less on the Richter scale) generated by hydraulic fracturing, color-coded by location along the wellbore. The modeling helps clients target — or in some cases avoid — fractures that are likely to slip during hydraulic fracturing.

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*

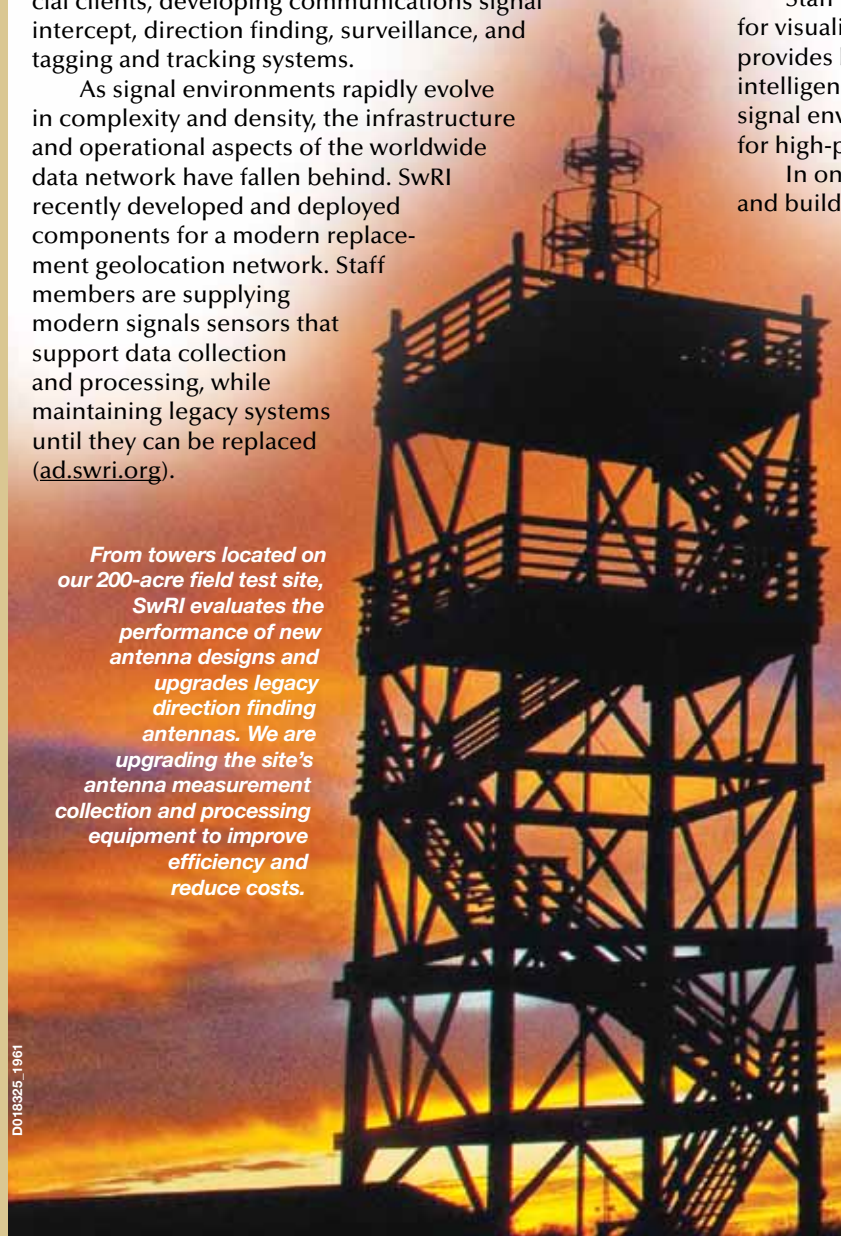
Ongoing threats to national security require timely intelligence data, including signal intelligence obtained through electronic surveillance. For more than 60 years, Southwest Research Institute has supported U.S. and friendly foreign governments, as well as commercial clients, developing communications signal intercept, direction finding, surveillance, and tagging and tracking systems.

As signal environments rapidly evolve in complexity and density, the infrastructure and operational aspects of the worldwide data network have fallen behind. SwRI recently developed and deployed components for a modern replacement geolocation network. Staff members are supplying modern signals sensors that support data collection and processing, while maintaining legacy systems until they can be replaced (ad.swri.org).

The huge volumes of data collected by intelligence sensors require new techniques for management, particularly as cloud-based systems are increasingly used for data storage. SwRI is developing new methods to retrieve, report, visualize and analyze large volumes of data to target specific information and observe trends (sed.swri.org).

Staff members are developing a real-time graphical user interface for visualizing signal spectral data and processed signal results that provides big-picture assessments from modern wideband signals intelligence systems. The GUI provides a dashboard for wideband signal environments, geomapping, audio output and threat indicators for high-priority targets.

In one of our longest-running programs, we continue to design and build antennas using innovative technologies for direction



From towers located on our 200-acre field test site, SwRI evaluates the performance of new antenna designs and upgrades legacy direction finding antennas. We are upgrading the site's antenna measurement collection and processing equipment to improve efficiency and reduce costs.

D018325_1961

D018578_8264

SwRI provided an end-to-end communications intelligence system for a small unmanned aerial vehicle (product engineering.swri.org). The novel antenna array and field-programmable gate array implementation supports tactical programs for VHF operations.

D018800

finding, communications and signal intercept applications (tacticalproducts.swri.org). We recently built and tested a ruggedized, very-high-frequency and ultra-high-frequency direction-finding antenna that integrates communications and electronics intelligence functions for shipboard applications.

We also developed an array of helix-loaded meandered loxodromic (HEMLOX™) spiral antennas that can assist in radiolocation of transmitters from medium-altitude airships. Radio transmitter locations are estimated near-instantaneously using responses from an array of these ultra-wideband, moderately directional antennas on a single, slow-moving platform (sse.swri.org).

Our internal research program keeps us at the forefront of digital signal processing, precision geolocation, numerical modeling and other technologies. In one project, we advanced our data mining capabilities by enhancing methods of modeling signal intelligence data to correlate significant patterns and changes with related global geopolitical events (se.swri.org).

We also developed a high-performance signal survey system that uses wideband technology and commodity computer servers to provide a variety of signal survey and signal discovery capabilities.

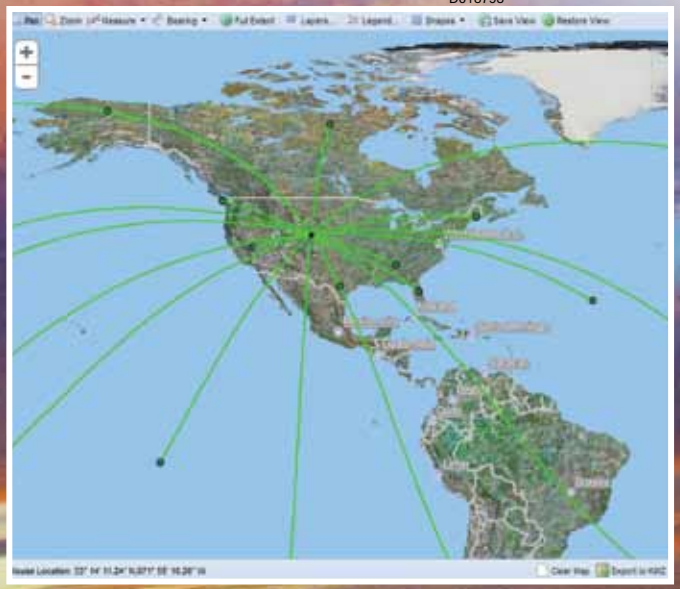
SwRI continues developing the Flashlight™ Soldier Combat Identification System to reduce friendly fire incidents on the battlefield (sgd.swri.org). This year, the system competed in national- and multinational-sponsored ground exercises to demonstrate combat identification technologies, performing well at ranges up to 18 kilometers.

Working with our space scientists and engineers, we are extending our digital communications expertise to the Defense Advanced Research Projects Agency System F6 program to assess the performance of a "fractionated" spacecraft — separate nodes connected wirelessly to form a virtual spacecraft, providing a reconfigurable alternative to future space missions compared to traditional spacecraft designs. Staff members are designing data communication and radio ranging signals and protocols, multiple access methods, and K_a-band radio hardware.

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. ❖

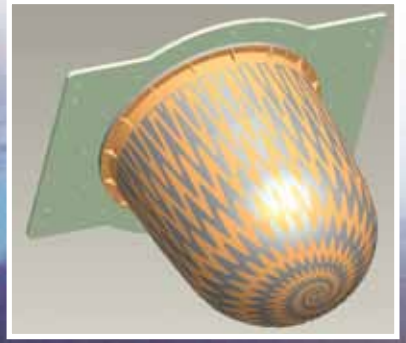
Visit sigint.swri.org for more information or contact Vice President Nils Smith at (210) 522-3685 or nils.smith@swri.org.

D018793



The nation's geolocation networking system architecture is based on approaches developed up to 60 years ago. Staff members developed a new extensible network architecture that significantly builds on the previous one with the added capability of supporting new and emerging signal threats (ad.swri.org).

D018799



SwRI engineers recently designed a new, patent-pending HEMLOX™ spiral antenna. Used in an array, these antennas rapidly locate radio transmitters from medium-altitude aircraft.

SwRI demonstrated the Flashlight™ Soldier Combat Identification System during national- and multinational-sponsored ground exercises. The ground-to-ground system uses low-power handheld devices to identify friendly forces at distances up to 18 kilometers (sgd.swri.org).

Applied Physics

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

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

SwRI scientists are collaborating with researchers at the University of Texas at Austin to develop a new theory to describe the behavior of electromagnetic radiation interacting with engineered composites, or metamaterials. This new theory will be instrumental in creating exotic lenses, antennas and nanoscopic transmission lines for the next generation of circuit designs and electromagnetic applications (advancedelectronics.swri.org).

Large robots have proven their worth to bomb squads and SWAT teams throughout the country and around the world. SwRI is now working with area police departments to explore using small tactical robots in police patrol operations. For example, using a robot to scout a building could decrease the number of SWAT calls, saving time and money.

To understand if robots will be effective and useful for these operations, SwRI is partnering with the National Institute of Standards and Technology to adapt current ASTM E54.08.01 response robot testing standards to meet the needs of patrol officers. These standards are tailored for urban search-and-rescue, bomb squad and military operations. SwRI is adapting these test methods to meet the unique needs of police officers working in stateside urban environments.

D018801

In a project for the National Institute of Standards and Technology, SwRI engineers helped design, build and run robot mobility test fixtures at Disaster City, a 52-acre facility in College Station, Texas, used to evaluate new robotic capabilities for use by emergency responders.

D018692_3179

Aftermarket automotive wheels are a common target for thieves because existing locking devices (such as keyed lug nuts) are easily cracked. In 2012, SwRI helped a small business develop a better wheel security device: a wireless electromechanical combination wheel hub cover that locks and unlocks using a password-protected smart phone application.

D018653_1657

As part of an internal research program, engineers used commercial systems to assemble a prototype mass spectrometer to measure the atmospheric composition of caves and wells. This portable, time-of-flight quadrupole mass spectrometer has many potential applications, including studying paleoclimates, local hydrogeologic activity, mine safety and carbon sequestration efforts, as well as analyzing a disease that is decimating bat populations in the eastern United States. Terrestrial caves also serve as analogs for planetary caves such as those found on Mars, which could be investigated for traces of astrobiological activity.

D018336_3795

In collaboration with SwRI space scientists, engineers developed a prototype mass spectrometer system using commercial components to survey the atmospheric composition inside four Texas caves. Caves contain tracers of current geological and biological activity, but up to this point, in situ *studies have been limited to sensors that monitor individual components of a cave atmosphere. The SwRI system can characterize the full atmospheric spectrum.*

To support the U.S. Department of Energy's SunShot Initiative to make solar energy cost-competitive, SwRI applied internal funding to develop a solar module that advances the state of the art in concentrated photovoltaic systems. ❖

Visit applied-physics.swri.org for more information or contact Vice President Ed Moore at (210) 522-2739 or ed.moore@swri.org.

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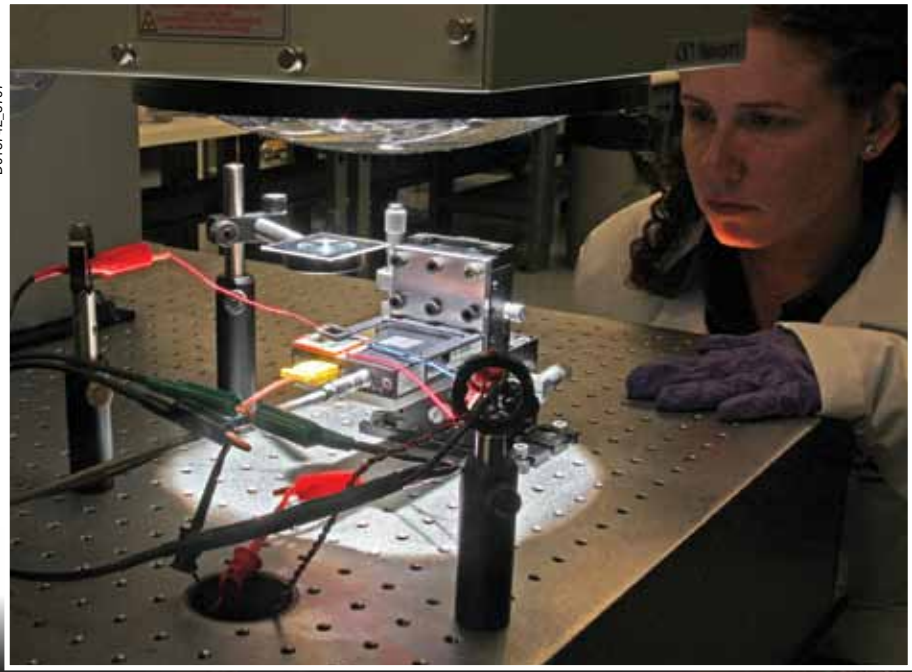


Using a solar simulator, we measure the efficiency of SwRI's optimized solar module.

The latest development in SwRI's non-lethal deterrent systems is the long-range ocular interrupter, also known as the laser dazzler. This device uses collimated laser light aimed up to several kilometers away to impede a potentially hostile target with dazzling, but eye-safe, visible light. We evaluated the system on a one-mile test range on the SwRI grounds.

Chemistry and Chemical Engineering

- *environmental engineering*
- *materials chemistry*
- *process engineering*
- *fire protection engineering*
- *demilitarization*
- *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*

Southwest Research Institute develops advanced chemistry and chemical engineering solutions to meet global challenges in areas ranging from alternative energy to human health and safety. We develop novel pharmaceutical formulations and delivery tactics using unique capabilities in micro- and nanoencapsulation technology. Working with industry and government, we also address environmental threats, food and fire safety, and homeland security concerns.

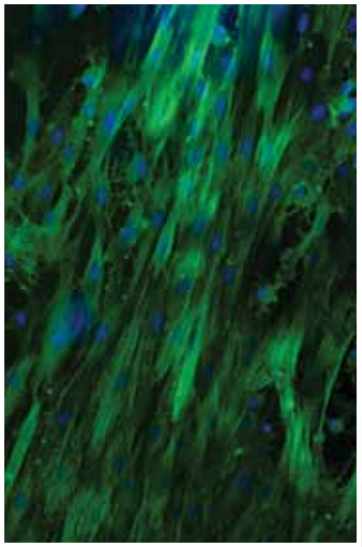
As the world continues to pursue cleaner renewable energy sources, carbon-based fuels will remain the primary source of energy in the near term. To reduce post-combustion carbon dioxide emissions, SwRI develops carbon capture systems for fossil fuel-based energy production. In 2012, we retrofitted lower-cost carbon capture systems on a client's pilot plant and investigated the optimal chemical pathways to economically store carbon dioxide in its developing commercial process (carboncapture.swri.org).

D018005_5464

Fire specialists are evaluating the efficacy of fire retardants in home furnishings, developing improved fire-growth and heat-release computer models, to address debate on the usefulness of fire retardants. Research showed that these compounds delay the fire growth and heat released in fires involving foam-filled chairs and couches, which would allow more time to escape from or respond to these types of fires (fire.swri.org).

As oil prices rise, developing huge North American shale and sand oil deposits becomes more commercially feasible, although costs and environmental concerns remain high. An SwRI-operated client feedstock test facility upgrades these heavy oils, offering significant cost and efficiency improvements (chemeng.swri.org). Environmental concerns associated with producing shale oil include the hazardous waste byproducts. In related work, SwRI is investigating a proprietary fracking fluid batch production process by reaction calorimetry.

To support the nuclear power industry, our fire technology specialists are collaborating with the Center for Nuclear Waste Regulatory Analyses to assess fire risk as part of relicensing of nuclear power plants. We have audited four power plants and identified opportunities for improved fire protection to enhance the safety of nuclear



D018787

We are developing implantable scaffolds, some perfused with therapeutic agents, for improved disease treatment and trauma, scar and soft-tissue repair. New delivery technologies include stem-cell-based scaffolds, novel materials such as metal organic frameworks and loaded aligned collagen, which can enhance tendon repair and bone regeneration (biomedical.swri.org).

D018749_9112

SwRI chemists quickly and cost-effectively assess risks associated with chemical and radiological residues in almost any medium, but particularly in food, soil and water, to characterize risks to human health and safety.

power plants in the United States. We are also testing materials used in Japanese nuclear power plants with the goal of reducing fire risk (fire.swri.org). In addition, we have unique facilities to store, handle and dismantle high-level radioactive sources and to irradiate items to specific dosages.

We are developing techniques to screen breath, saliva and blood to investigate biomarkers of obesity, cardiovascular disease and radiation exposure. SwRI chemists are collaborating with local biological researchers to identify unique biomarkers and to characterize biological samples using an ultra-high-resolution, two-dimensional, time-of-flight mass spectrometer. This research could lead to accurate, rapid and minimally invasive life-saving screening methods.

SwRI is becoming increasingly well known for developing novel formulations and delivery techniques for countermeasures to chemical, biological and radiological threats, including cyanide, chlorine and other nerve agents. In 2012, a nanosuspension formulation of a chemical weapon antidote entered phase 1 clinical trials (microencapsulation.swri.org).

Our medicinal chemistry experts are working with government and industry to produce targeted-delivery compounds, materials and devices ranging from nutraceuticals and cancer therapies to wound healing technology and an anti-addiction implant (synchemistry.swri.org). We are developing new drug delivery, targeting and release platforms using scalable processes to prepare microparticles and resorbable nanoparticles for cellular, mucosal, transdermal, ocular and oral delivery (drugdelivery.swri.org).

For more than 25 years, we have played a role in the safe destruction of chemical warfare agents at four U.S. storage facilities, collecting and analyzing environmental samples to assure the safety of workers, the public and the site. In 2012, we supported the completion of site remediation in Pine Bluff, Ark., and continuing efforts at a plant in Umatilla, Ore. ❖

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

D018791

For green energy applications, SwRI scientists are designing high-temperature microencapsulated phase-change materials to store thermal energy for solar power applications. We have designed capsules with a shell that remains intact above 600 degrees Celsius to store thermal energy in a core material that melts at approximately 350 degrees Celsius (microencapsulation.swri.org).

D018443_4070

For the Department of Homeland Security Chemical Forensics program, we developed techniques to analyze dust as a natural collection medium for chemicals. Characterizing the chemical signatures can provide clues to the source and history of chemicals, such as agents used in malicious attacks. In another DHS program, SwRI is researching ultra-high-capacity, moisture-resistant metal organic framework materials to collect volatile and semi-volatile compounds after chemical exposure (environmentalchemistry.swri.org).

Consolidated Financial Statements

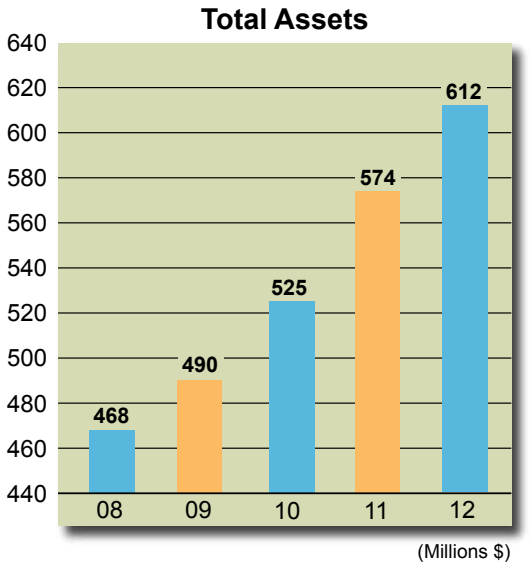
For the years ended September 28, 2012, and September 30, 2011

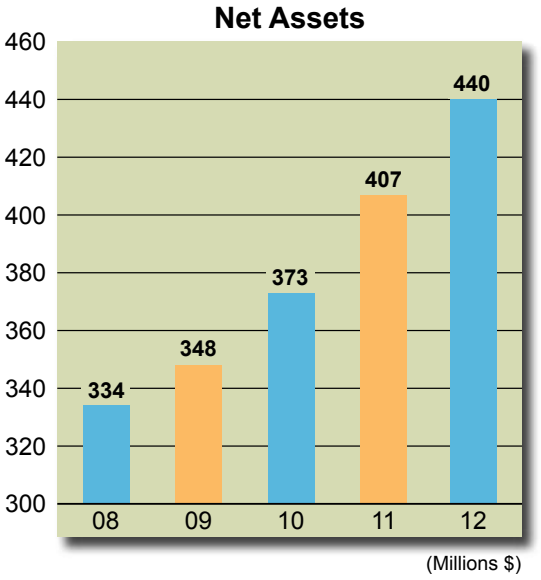
Income Statements (in thousands of dollars)

	2012	2011
Revenue	$584,242	$581,385
Direct Project Costs	346,703	347,446
Operating Income	237,539	233,939
Division Operating Expenses	130,481	126,687
General Overhead	54,632	56,853
Depreciation — General Facilities	15,343	14,808
Internal Research	7,426	6,123
Realized/Unrealized (Gain) Loss on Postretirement Medical Funds	(6,641)	725
Income Before Federal Income Tax Expense	36,298	28,743
Federal Income Tax Expense	326	352
Net Income	$35,972	$28,391

Balance Sheets (in thousands of dollars)

	2012	2011
Current Assets	$239,712	$243,969
Property and Equipment, Net	275,755	263,439
Other Assets	96,157	66,213
Total Assets	$611,624	$573,621
Current Liabilities	$99,106	$99,332
Noncurrent Liabilities	72,412	67,560
Net Assets	440,106	406,729
Total Liabilities and Net Assets	$611,624	$573,621





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