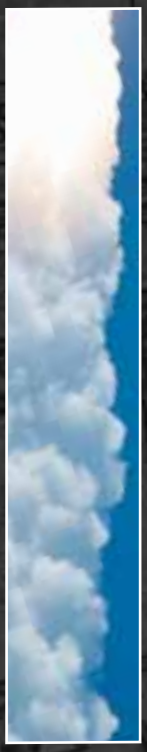
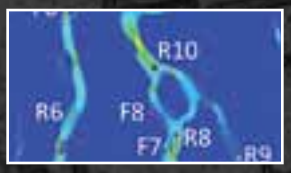
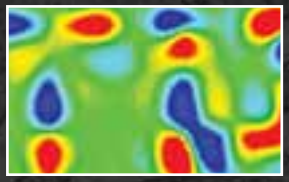
Southwest Research Institute®

2011

annual report







Southwest Research Institute®

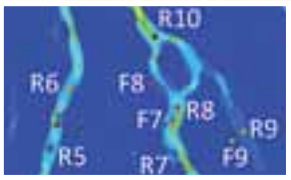
Benefiting government, industry and the public through innovative science and technology

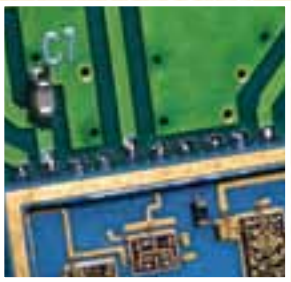
Southwest Research Institute is an independent, nonprofit, applied engineering and physical sciences research and development organization using multidisciplinary approaches to problem solving. The Institute occupies more than 1,200 acres in San Antonio, Texas, and provides more than 2 million square feet of laboratories, test facilities, workshops and offices for more than 3,000 employees performing contract work for industry and government clients.

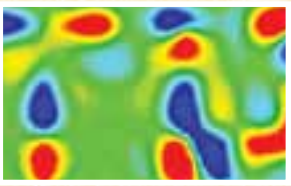
Contents







Message from the President

Despite the turbulent global economic markets, Southwest Research Institute had another successful year. Revenue — the total amount of research conducted — was the highest in our history. As we continue to advance science and technology in support of government and industry clients, it is an honor to submit this annual report outlining a range of our technical programs and achievements throughout the past year. I know you will appreciate the varied and far-reaching effects of the Institute's efforts.

The ebb and flow of events over the past year created new opportunities for the Institute. The recent explosion in exoplanet discoveries is defining a major new market with new funding sources. The explosive growth of shale gas production in the U.S. presents new production and transportation challenges. At the same time, revitalized markets, such as compressed natural gas as a transportation fuel, are providing additional opportunities.

Our space program continues to literally reach new heights. In August, NASA's Juno spacecraft began its five-year journey to Jupiter, where it will orbit the giant planet to improve our understanding of the solar system's beginnings. We were the first science organization to contract for payload specialists to conduct research aboard commercial next-generation suborbital spacecraft. The SwRI-led Interstellar Boundary Explorer mission, which continues the most comprehensive study yet of the global interactions occurring at the outer reaches of the solar system, was listed by *Discover* magazine as one of the top 100 science stories.

Internationally, we developed working relationships to advance science and technology. We signed a three-year strategic alliance agreement with India's Council of Scientific and Industrial Research to cooperate in the development of novel technologies in fuels research and engine development. We increased our presence in China, enlisting Beijing BSS Corrosion Protection Co. Ltd., to represent the Institute's interests in products and services related to sensor systems, nondestructive evaluation, surface engineering, coatings and corrosion.

The Institute launched an alternative fuel technology center and two new consortia to address pressing issues in automotive technology. The International Alternative Fuel Technology Center helps clients reduce dependence on fossil fuels and meet governmental mandates for alternative fuel production and tightened emissions standards. The Pre-ignition Prevention consortium seeks new ways to suppress low-speed pre-ignition. The Energy Storage System Evaluation and Safety consortium provides transparency in the automotive battery market to advance the development of energy storage systems.

Many staff members gained prestigious recognition for their professional achievements. Peer-reviewed papers, presentations, patents and other activities document their contributions to advancing science and technology. We collected our 36th R&D 100 Award from *R&D Magazine* for an automotive ignition system. The Highlights section of this report details additional staff accomplishments.

The internal research program, designed to advance the Institute's technology base, is a vital technical component that provides Institute engineers and scientists the freedom to explore innovative concepts. In 2011 we initiated 67 projects and spent more than $6.1 million on internal research. Many of these projects are detailed throughout this report. Locally, SwRI expanded its collaboration with The University of Texas at San Antonio by establishing a seed fund for experimental internal research and development as well as partnering with the university to offer a doctorate in mechanical engineering.

We undertook comprehensive infrastructure improvement projects, including reconstructing the Institute's main surface road network. We initiated a major expansion of our dynamometer test cell facilities as well as an upgrade of the fitness center that will encompass more than 25,000 square feet to benefit employee health and wellness.

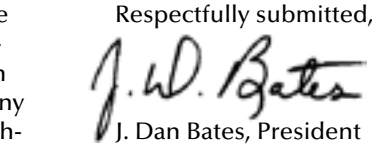
Each year, the generous support of staff members through volunteer efforts and donations to community organizations continues to grow. The United Way campaign received more than $746,000 in pledges and contributions.

The fluctuating economic and political landscape requires that we strive to maximize our technical strengths and resources while diligently managing costs to ensure that we meet strategic and fiscal goals. Our technical programs generated revenues of $581 million, compared to last year's $548 million with net income of $28 million for 2011. Total payroll to our 3,046 employees was more than $232 million.

Encouraging signs for a successful year in 2012 include a robust backlog of contracts and proposals, including contracts to develop a nasal-delivery treatment system to combat cyanide poisoning, and to design and test a full-scale, multi-stage centrifugal compressor to further carbon dioxide compression research.

As we have seen repeatedly in our 64 years of operation, we constantly adapt to a changing environment as programs come to an end and new programs develop. But our goals of outstanding service plus the resolute effort, support and vision of our staff, advisory trustees and Board of Directors, give us confidence that we will continue providing quality technical services and research for clients in 2012 and beyond.

Respectfully submitted,



J. Dan Bates, President

Highlights

Southwest Research Institute continues as a pioneer in basic **space science research** and the development of **spacecraft instrumentation and avionics**. An SwRI scientist is the principal investigator for NASA's **Juno mission to Jupiter**, which successfully launched in August. The spacecraft also carries two SwRI-designed and -built instruments — the Jovian Auroral Distributions Experiment and the Ultraviolet Spectrograph — that will study Jupiter's powerful aurora and investigate the magnetic-field-aligned electric currents that flow between the ionosphere and the magnetosphere.

We installed the largest-ever, **dual-robot system** to **remove coatings** from U.S. fighter aircraft. We also are evaluating the use of high-speed lasers for coating removal that could prove more environmentally friendly than chemical and blast removal methods.

For the automotive industry, staff members kicked off two new consortia, the **Pre-ignition Prevention Program** for evaluating fuels and lubricants to discover methods for suppressing low-speed pre-ignition and the **Energy Storage System Evaluation and Safety** program for developing cell-level test data on electrochemical storage systems and advancing testing methodologies to evaluate batteries. Another effort, the **International Alternative Fuel Technology Center**, addresses government mandates for alternative fuels production and stringent emissions standards.

Staff members are developing a **nasal delivery formulation** for an amyl nitrite countermeasure to **cyanide poisoning** that can be self-administered rather than injected by medical personnel, enabling quick and effective treatment for large numbers of casualties.

This year, our **Automation and Data Systems** Division was once again appraised at **Level 5**, the highest level of the **Software Engineering Institute's Capability Maturity Model® Integration** for Development, V1.3. The **Signal Exploitation and Geolocation** Division was appraised as operating at the **Defined Maturity Level 3** of CMMI® for Development, V1.3.

Several of our researchers received **national recognition** for professional accomplishments. The American Geophysical Union awarded Dr. James Burch its 2010 John Adam Fleming Medal. The Division for Planetary Sciences of the American Astronomical Society awarded the Kuiper Prize in planetary sciences to Dr. William Ward. Dr. Terry Alger received the Society of Automotive Engineer's Forest R. McFarland Award. Staff members honored as Fellows include Dr. Marc Janssens, named a Fellow of the Society of Fire Protection Engineers; Dr. David McComas, named a Fellow of the American Physical Society; and Dr. Charlie Roberts, named a Fellow of the Society of Automotive Engineers.

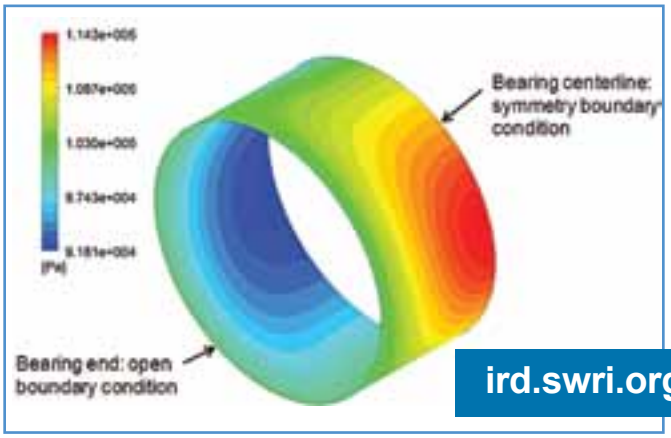
The **SwRI staff** numbered 3,046 employees. Of those, 275 hold doctorates, 499 hold master's degrees and 762 hold bachelor's degrees. The Institute received 34 U.S. patent awards, filed 65 patent applications and submitted 66 invention disclosures. The technical staff published 507 papers and gave 500 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 2011, SwRI initiated 67 new projects and spent more than $6.1 million on internal research. Some of this year's projects include:

digitally controlled high-voltage power supplies for space applications • mass spectrometer application in a natural gas analyzer • ammonia combustion with selective catalytic reduction aftertreatment • COMINT geolocation using ad hoc networking communications transceivers • magnetostrictive transducer probe technology • tactical aerobotic launch system • transplantable vascularized cell constructs to accelerate wound healing • 3-D imaging for behavior classification • robust compressor station design methodology • multiscale modeling of an armor composite • intra-vehicle location finding using inexpensive sensors • lighter-than-air vehicle gas leak rate measurement • corrosion measurement in fuel systems • coupled fluid flow and rock deformation analyses in reservoir simulations • organophilic, compliant platelets for fire-resistant tire and tread formulations • mobile augmented reality as a learning tool • special purpose IP routing • temporally coherent communications • next-generation, high-performance spaceflight computer • spherical position sensor for a 3-D laser metrology system • targeted formulation to treat spinal cord injury and other neurological disorders • solution-based diamond-like carbon coatings • multidimensional controls framework for diesel fuel-air management • pulsed-laser synthesis of group IV clathrates for energy storage applications • stabilized dispersive focal plane system • epikarst effects on recharge and storage of groundwater in karst aquifers • coupled mechanistic model to examine aerosol migration in the atmosphere • alternative coatings to reduce and/or eliminate bridging oxidation • selective noncatalytic reduction system for stationary NO_x emission control



Staff members are modeling foil gas bearings used in high-performance turbomachinery, as well as performing experimental tests, to assess the performance of these oil-less component designs.

ird.swri.org

Automotive Engineering

Since the inception of the automobile, engine and vehicle design, as well as fuel and lubricant development, has steadily evolved, all the while keeping pace with increasingly stringent regulations and constraints. Southwest Research Institute has a more than 60-year history of providing quality fuel and lubricant evaluation services, specialized vehicle designs, and innovative engine, component, and emissions control research and development that meet and exceed client objectives (oae.swri.org).

Our engineers developed the award-winning DCO™ Ignition System through the High-Efficiency Dilute Gasoline Engine cooperative industry program managed by SwRI. The consortium closed 2011 with 25 members, becoming the largest gasoline engine research cooperative in the industry (hedge.swri.org). The HEDGE® program develops the enabling technologies needed to advance gasoline engines to meet the performance, durability and emissions requirements of future motor vehicles.

Our longest-running consortium, Clean Diesel, is now the Clean High-Efficiency Diesel Engine program, reflecting a shift from reducing diesel engine emissions to improving engine efficiency at current emission levels (chedevi.swri.org). Research is targeting alternative combustion concepts, hybrid diesel systems and advanced model-based control systems to meet these goals.

We launched two new cooperative programs this year. The Pre-ignition Prevention Program is evaluating fuels and lubricants to discover ways to suppress low-speed pre-ignition, which causes the heavy engine knock that can seriously damage engine components or cause engine failure (pppconsortium.swri.org).

Safe, reliable, cost-effective energy storage systems for electric and hybrid-electric vehicle applications are the focus of the Energy Storage System Evaluation and Safety consortium. EssEs is helping vehicle manufacturers and battery suppliers develop cell-level test data on electrochemical storage systems and advancing testing methodologies to evaluate batteries (esses.swri.org).

These and other SwRI industry consortia enable member companies to leverage the return on their contributions by the total number of members, funding significantly more precompetitive research than would be possible otherwise (consortia.swri.org).

To reach U.S. Environmental Protection Agency Tier 4 locomotive particulate matter (PM) standards, we collaborated with Johnson Matthey and a major Western railroad to retrofit a 2,100-horsepower genset locomotive with a Johnson Matthey CRT® diesel particulate filter

D017817_0285

We designed a new test stand to evaluate the effects of lubricating oils on camshaft roller follower axles in commercial and military engine applications. The test also measures lubricant viscosity, total base number and specified wear.

D018239 *Courtesy Staff Sgt. Shane A. Cuomo, U.S. Air Force, DOD*

To improve fuel economy in the Bradley Fighting Vehicle, staff members are developing an advanced power take-off drive system constructed to fit within the space constraints of the current vehicle design.

system. Assessments show a reduction in particulate matter emissions of about 95 percent — levels one-tenth of those required to meet the 2015 Tier 4 standards. The retrofitted locomotive began a year of revenue service testing in July 2011, operating near the ports of Long Beach and Los Angeles (locomotive testing.swri.org).

Using internal research funding, engineers designed and developed an automotive wet clutch system that can reduce parasitic losses when the clutch is not in use. Using advanced lubrication and cooling methods, concept testing proved to reduce clutch drag losses by 50 percent with no impact on overall durability. This effort has led to multiple client-sponsored programs and the expansion of clutch development activities, which now support complete clutch system hardware-in-the-loop development.

◆ ***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 research***
◆ ***emissions reduction*** ◆ ***transmission design***

Working closely with the U.S. Army's TARDEC Ground Vehicle Power and Mobility, SwRI is developing an advanced power take-off drive system to improve fan drive efficiency and increase on-board electrical power generation in Bradley fighting vehicles. Modeling and simulation indicate that the addition of a multi-speed stepped ratio drive provides improved fuel economy over the baseline fluid coupling.

TARDEC's Fuels and Lubricants Research Facility at SwRI provides dedicated service to the Army fuels and lubricants technical program as well as other government entities and industry (tardec.swri.org). SwRI supports the evaluation of turbine and diesel fuels produced from alternative and renewable feedstocks. Army and SwRI laboratories continue to expand capabilities to support fit-for-purpose testing beyond the scope of standard specifications for jet and diesel fuels.

D017977_2630

Our engineers modified a cold box to measure the time it takes oil to reach various engine components at extremely low temperatures. The test cell also evaluates flow, wear and other operating parameters at temperatures as low as minus 40 degrees Fahrenheit.

D1M018043_8972

R&D Magazine *named our DCO™ Ignition System one of the 100 most significant technological achievements of the past year. The novel system will allow gasoline engines to meet or exceed the efficiencies of diesel engines, but with the lower emissions of gasoline engines. This technology results in cleaner emissions, lower fuel consumption and less potential for engine "knock."*

Automotive Engineering *cont'd*

Working closely with fuel producers, air framers, engine manufacturers, federal agencies and the military, SwRI investigated emerging synthetic aviation and ground fuels, including paraffinic kerosenes developed from the Fischer-Tropsch process and hydroprocessed esters and fatty acids. The fuels are being rigorously examined as possible replacements for conventional petroleum-based fuels.

Staff members launched the International Alternative Fuel Technology Center (iaftc.swri.org), a collaborative effort to address government mandates for alternative fuels production and stringent emissions standards. The center combines SwRI's decades of experience in fuels and emissions research with expertise from a variety of disciplines to address these complex issues.

Because of rising fossil fuel costs and concerns about the environmental effects of carbon dioxide, staff members are examining multiple alternative fuels for internal combustion engines. One client effort investigated the feasibility of using ammonia as a fuel because it can be produced from renewable sources and produces no carbon dioxide emissions. Staff members successfully ran an engine powered by ammonia, identifying challenges with the fuel burn rate and exhaust gas.

In 2011, we significantly expanded the facilities and capabilities available to our automotive and fuels and lubricants clients. We recently constructed four new mileage accumulation dynamometer lanes. One dyno offers four-wheel-drive capabilities and supports hybrid vehicle testing under real-world conditions. All four of the new lanes have temperature- and humidity-controlled engine inlet air to ensure consistent operating conditions year-round.

For our clients that formulate off-highway lubricants, we recently designed and built a test stand to evaluate how oil formulations affect the life of oil-lubricated clutches in tractor transmissions. Test stand operation is automated and uses our Prism® data acquisition and control software to manage critical parameters such as clutch slip energy and oil temperatures.

SwRI is upgrading its heavy-duty transient dynamometer facility to meet Environmental Protection Agency Part 1065 requirements for emissions testing of modern heavy-duty engines. The upgrades also will supply the precision needed to develop and certify modern low-emissions engines.

D1M017976_3151

D1M018244_9702

SwRI completed construction on four new mileage accumulation dynamometer lanes that complement the 20 already in operation. Used for fuel, lubricant and vehicle power train testing, the new lanes have temperature- and humidity-controlled engine inlet air to ensure consistent operating conditions year-round.

To support our EssEs consortium, staff members have equipped three new test labs to evaluate battery cells of any chemistry. The labs support characterization/performance, abuse/safety, life and manufacturability tests on cells of any form factor. The labs also can measure out-gassing and emissions from crush and other destructive tests, and flammability of emissions and effluents.

◆ ***natural gas engine development*** ◆ ***materials compatibility***
◆ ***alternative fuel evaluations*** ◆ ***powertrain modeling & controls development***
◆ ***high-efficiency gasoline engine research*** ◆ ***particle science***
◆ ***engine development*** ◆ ***generator set & combined heat & power evaluations***
◆ ***homogeneous charge compression ignition*** ◆ ***hydraulic design***
◆ ***hardware-in-the-loop evaluations*** ◆ ***hybrid vehicle design***
◆ ***light-duty fuel economy & production calibration*** ◆ ***contamination research***
◆ ***wear evaluations*** ◆ ***vehicle testing*** ◆ ***accelerated durability evaluations***
◆ ***energy storage technologies***

filters under stringent new solid-particle emissions standards for diesel engines. Switzerland has the most stringent limits on solid particle numbers, specifying an emission limit for particles in the range of 20 to 300 nanometers in diameter. Engines equipped with diesel exhaust particle filters must meet solid particle number filtration efficiencies of 97 percent or greater. ❖

SwRI strives to provide the highest levels of quality and environmental management in the products and services offered to clients. Automotive engineering certifications include ISO 9001:2008, ISO/IEC 17025:2005 and ISO 14001:2004, as well as other service-specific certifications and accreditations.

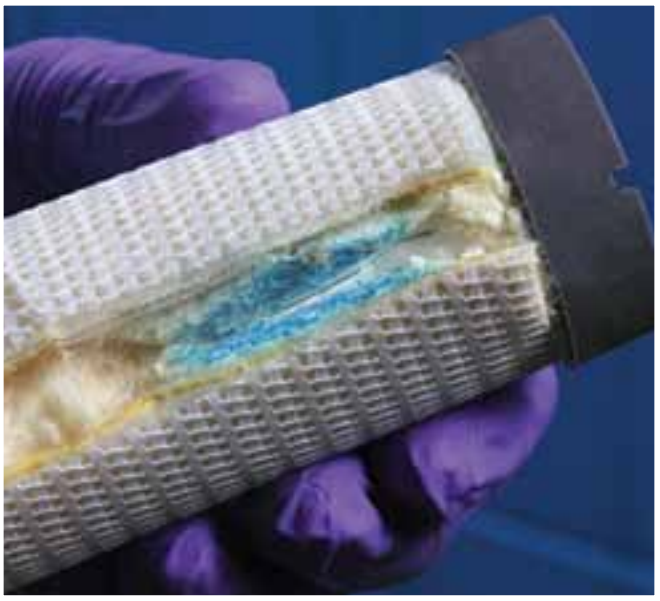
This year, SwRI also received accreditation from the Swiss Federal Office for the Environment to evaluate engine exhaust

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.

D018178_5063

Using internal research funding, we designed a new wet clutch system that decreases parasitic clutch drag by 50 percent with no impact on overall clutch durability.

D1M01845_9436



SwRI researchers recently investigated the effects of super-absorbent polymers, which remove trace amounts of water from aircraft fuel. Evaluations showed SAPs play a role in reducing the life of aircraft fuel filters, leading to unscheduled aircraft maintenance. The blue stain in this cutaway of a fuel water monitor indicates the presence of polymers.

Automation and Data Systems

Southwest Research Institute is using advances in computer-, automation- and network-based technologies to solve problems and create new products for our government and industry clients. We are developing hardware and software solutions for diverse challenges in the energy, aerospace, transportation, manufacturing and security arenas. Our software engineering activities have been appraised at Level 5 of the Software Engineering Institute's Capability Maturity Model® Integration, the highest level and a distinction held by a very small number of organizations (softwareengineering.swri.org).

In 2011, we released the first version of "Vehicular Integration for C4ISR/EW Interoperability (VICTORY) Standard Specifications" to revolutionize and streamline how the military adds critical subsystems to its tactical vehicles. The new VICTORY standards will provide a foundation for interoperability among on-board sensors and weapon systems, enabling a level of situational awareness not previously possible and resulting in increased soldier survivability and effectiveness (networks.swri.org).

We continue enhancing two large statewide intelligent transportation systems projects in Texas and Florida, integrating connected vehicle technologies into advanced traffic management systems, creating smart phone applications for field management of incidents and demonstrating new concepts for managing traffic for environmental benefits. SwRI is also implementing a dynamic lanes project — changing lane directions based on traffic conditions — to solve a significant traffic problem in southern Florida (its.swri.org).

Our analysts are helping the Veterans Administration implement an adverse drug effects tool, a decision support system that will alert VA medical personnel when a patient is at risk for having an adverse drug reaction based upon changing patient medical and demographic conditions. We are also continuing the development of the VA Pharmacy Re-Engineering program that will facilitate getting new medications approved, rapidly update pricing information and reduce mistakes by automating updates (intelligentsystems.swri.org).

The rollout of smart grid technology promises increased reliability and efficiency in the nation's power grid, but the two-way communications between control centers and field devices must be hardened against cyber attack. SwRI is supporting the implementation of the smart grid in standards development and cyber security, conducting penetration testing exercises to identify system vulnerabilities and providing mitigation recommendations (smartenergygrid.swri.org). In the broader area of cyber security, SwRI analysts developed a unique extreme value theory anomaly detection approach

D018221

Courtesy Boeing

The Institute is developing the latest in flight test technologies, pioneering the use of novel network-based data acquisition and recording systems. The SwRI system accumulated more than 10,000 flight test hours during certification flight test programs of Boeing's most recent commercial airplanes (nbi.swri.org).

D018241_9375

For the past five years, SwRI has been funding multidivisional research into unmanned vehicle technologies through what is now known as the Mobile Autonomous Robotics Technology Initiative (marti.swri.org). We have developed an autonomous vehicle platform to demonstrate a variety of technologies, including cooperative vehicle, sensor system, path planning and military applications. In 2011, we began a project for the military that applies this research, developing a low-cost electro-optical sensor suite coupled with advanced autonomy software.

that shows significant promise in detecting fraud and malicious insiders.

In 2011, we installed the largest-ever dual-robot system to remove coatings from fighter aircraft for the U.S. Air Force. We used the system to conduct a large-scale demonstration of a high-speed laser coating removal technology, an innovative technique that could prove more environmentally friendly than current chemical and blast removal methods (robotics.swri.org).

To expand other large-scale robotics applications, SwRI developed a mobile manipulator system that uses remote sensing to accurately position an end effector in a large work space. Using an off-the-shelf industrial robot, a mobile platform and a metrology system, we developed a versatile robotic system able to operate in a large workspace without costly mounting systems that often limit mobility and flexibility (mobile manipulator.swri.org).

To help keep manufacturing jobs onshore, SwRI operates a regional office of the Texas Manufacturing Assistance Center, a federal program to help small- and medium-sized manufacturers in Texas become more competitive in the global economy. This year, we began working with technology incubators to provide startup businesses with crucial design, analysis and other technical services (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.

- enterprise software
- cyber security
- automated inspection
- green efficient manufacturing
- process re-engineering
- embedded systems
- image & signal processing
- machine vision
- perception systems
- process improvement
- autonomous vehicle technologies
- tactical networks
- robotics
- high-performance computing
- SEI CMMI® Level 5
- intelligent transportation systems
- smart grid security
- cooperative vehicle technologies
- aerospace networks
- control center software
- GHG reduction
- MEMS & microfluidics
- data management & mining
- lean manufacturing
- situational awareness
- wireless sensor networks
- high-reliability software
- network-centric systems
- decision support systems

D018158_1647

D018223

Engineers developed, delivered and installed the largest dual-robot system of its kind to depaint advanced fighter aircraft, drawing on SwRI's 25-year history in custom, large-scale robotic system design.

Using Chip-Scale Atomic Clock technology developed initially with DARPA funding, SwRI designed small, low-power atomic clock technology for mobile wireless communication applications, such as cell phones and military radios. Using internal funding, we applied CSAC devices to create novel waveforms that take advantage of the highly synchronized clocks in transmitter and receiver radios.

Aerospace Electronics, Systems Engineering and Training

Southwest Research Institute provides products and engineering services to the domestic and foreign aerospace industry, offering particular expertise in aerospace propulsion, electronic systems, components and training technologies. Staff members continue working with the U.S. Air Force to modify and upgrade critical aircraft and engine monitoring subsystems and support equipment to expand the capabilities of the A-10 Thunderbolt. These upgrades are part of the most extensive modification effort in the history of the aircraft, designed to extend its service to 2038 (aircraftsystems.swri.org).

The U.S. Air Force relies on continuous turbine engine monitoring to assess the health of aircraft propulsion systems pre-flight, in-flight and post-flight. Software-controlled diagnostic processes are updated with the development of new techniques that are pushing the limits of legacy hardware and processor products. SwRI is developing an intelligent engine monitoring system "Dash-50" processor board to better assess engine health. We prototyped and qualified the device, and clients are flight testing the equipment. We also are developing a digital signal processor-based vibration analysis card for the Air Force that is undergoing flight evaluations (avionics.swri.org).

SwRI is developing new technologies for jet engine test cells. Using internal research funding, engineers successfully demonstrated test cell correlation without a dedicated engine for many applications, which could offer tremendous cost savings for test cell operators. We are implementing condition-based maintenance programs at the new Corpus Christi Army Depot in Texas, including the Smart Transmission Test System, which uses the nSPCT™ n-variable statistical process control tool to detect operational anomalies in complex monitored systems. We also used the nSPCT tool to help a commercial client isolate the root cause of a previously undiagnosed chemical processing failure (nspct.swri.org).

Electronic warfare equipment — a variety of systems designed to confound combatant communications, tracking and targeting technologies — typically consists of stand-alone pods or replaceable units installed on or in an aircraft. In 2011, SwRI rapidly developed and tested a software solution for an AN/ALQ-131 electronic attack pod malfunction. We also are performing ALQ-131 electronic warfare pod independent validation, verification and software maintenance and are providing

D1M018209_9187

Engineers contributed expertise in autonomous systems to the multidisciplinary, internally funded Mobile Autonomous Robotics Technology Initiative, known as MARTI®. In 2011, we upgraded original hardware with a new low-level, more rugged controller, which is a fraction of the size and cost of the previous system (pathplanning.swri.org).

D017247_2037

SwRI is developing an intelligent engine monitoring system using the "Dash-50" processor board to support advanced aircraft propulsion system health assessments. Engineers developed a Gold Improved Electronic Processor Unit featuring the new technology, which will be utilized at A-10C bases worldwide as a troubleshooting tool until the "Dash-50" is deployed fleet-wide.

D018222 *Courtesy Airman Jerilyn Quintanilla, U.S. Air Force, DOD*

Engineers supported the U.S. Air Force A-10C Suite-7B upgrade, which will enter flight test and deployment next year. SwRI also won every significant avionics design competition for the A-10C, including contracts to upgrade the common armament tester, vibration card, windshield electronics and boresight systems.

innovative software updates to address legacy hardware problems and enhance pod capabilities quickly, without costly hardware updates.

We delivered a unique program to the U.S. Air Force, which could be applied to any organization concerned with losing valuable corporate knowledge to retirements and attrition. The Expert Knowledge Transformation process quantifies knowledge loss risks, elicits the tacit wisdom and transforms the captured expertise. The newly captured wisdom is modeled for the current organization and workforce so that less experienced staff members can adapt these techniques in the context of current practices (emergingtech.swri.org).

◆ 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)

The proliferation of advanced mobile devices with powerful processors, large screens and abundant memory has created new opportunities for delivering training and performance support. SwRI is applying internal research funds to investigate and validate criteria for mobile learning. Expanding upon previous research in criteria-based models for learning content delivery, we are comparing task performance differences resulting from a range of representative applications including simple two-dimensional performance support tools, to three-dimensional simulations and mobile augmented reality (tspi.swri.org).

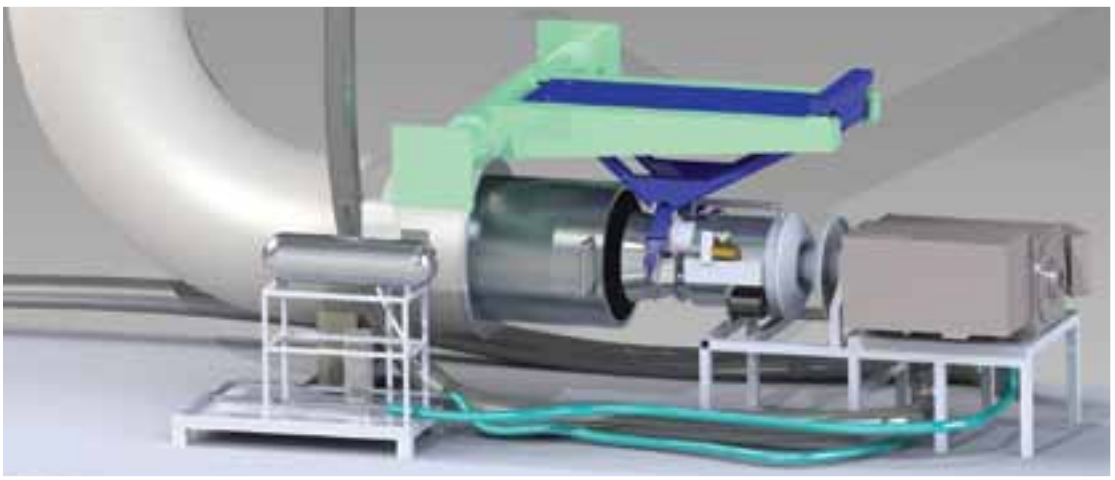
In 2011, these activities were certified to Aerospace Standard AS9100 Revision C and ISO 9001:2008, placing us in the top 15 percent of 13,000 aerospace firms worldwide. ❖

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

D018236

Training specialists created an interactive simulation to help parents and caregivers learn the most successful interventions to use when interacting with individuals with challenging behaviors, such as those associated with autism. The first level of the game-based Behavior Breakthroughs™ software was available as a smartphone app, and the comprehensive PC- and Mac-based programs can be purchased online (behaviorbreakthroughs.com).

D018238



SwRI is developing a groundbreaking high-speed direct-drive load system to test rebuilt helicopter engines before they are put back into service. Our turbo shaft test cell design, shown in this computer model, will require significantly less maintenance and downtime than the existing equipment, and the energy they absorb can potentially be fed back into the local power grid to offset energy costs.

Mechanical Engineering

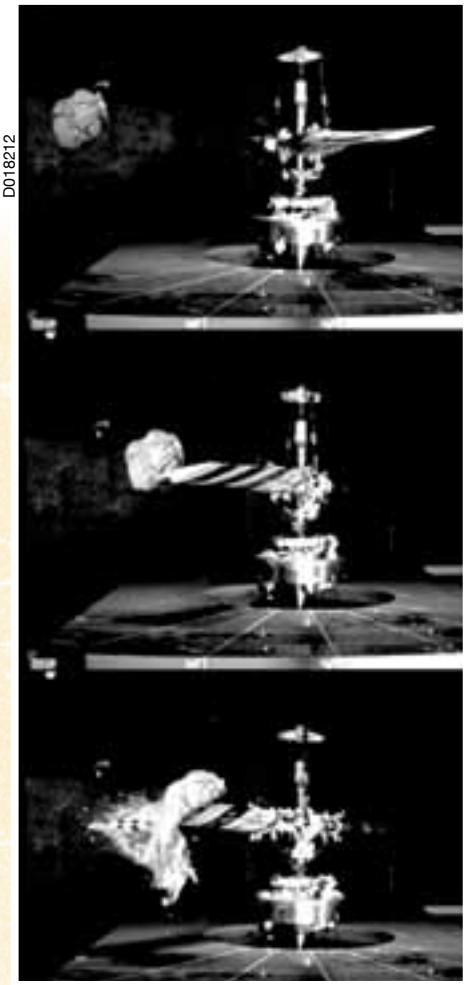
Southwest Research Institute continues to support the energy, aerospace and defense industries by applying expertise in materials, structures, sensors, fluids and dynamics to help our clients extend the life and improve the safety, reliability and efficiency of their systems. Core areas of research include oil and gas production and transmission, renewable energy, military and commercial aircraft, manned submersibles, space hardware and military ground vehicle armament.

SwRI expanded and diversified its mine blast and improvised explosive device mitigation research and development. In addition to studying armored tactical vehicles, we also investigated personal protection equipment designs and developed and demonstrated a human head surrogate to assess blunt trauma injury associated with ballistic helmets under blast conditions (engineeringdynamics.swri.org).

Our scientists are developing a unique anode material aimed at significantly extending the range, life and power density of lithium-ion batteries, particularly for electric and hybrid-electric vehicle applications. Scientists are investigating techniques to store lithium ions in the cage-like structure of silicon clathrate to provide higher energy density and longer battery life. Project tasks include investigating new ways to make clathrates, modeling the behavior of the anode material and developing and evaluating a prototype battery cell.

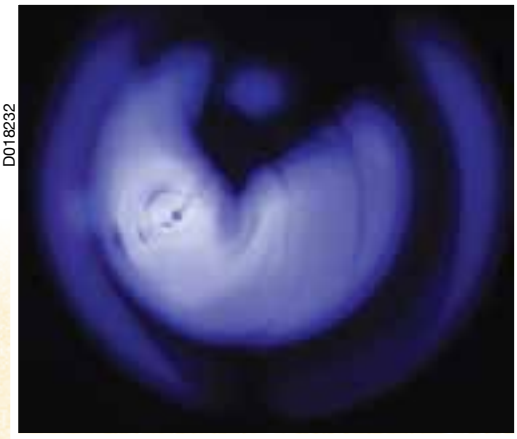
In 2011, we began the third phase of a $10 million U.S. Department of Energy program to develop more efficient carbon dioxide compression systems for clean coal applications. Engineers are developing a full-scale, multi-stage centrifugal compressor with internal cooling, a CO_2 liquefaction plant, and a liquid pumping station to boost the pressure of carbon dioxide emissions from pulverized coal, integrated gasification combined cycle, and oxy-fuel

D018212



SwRI supports aircraft damage tolerance and survivability programs, conducting impact testing of stationary and rotating targets. This series shows high-speed images of a simulated bird strike on a helicopter blade (impacteval.swri.org).

D018232



Our materials scientists are developing a range of plasma processing techniques to enhance material properties to reduce friction and improve wear and surface energy. This plasma immersion ion deposition process applies unique coatings over large areas (surfaceengineering.swri.org).

D1M018030_9595

To support our aircraft structural evaluation and life extension programs, SwRI conducts destructive teardowns of high-flight-time wings removed from service to thoroughly inspect for hidden damage. Such information provides insight about wings still in service and allows aircraft maintainers to better focus future inspections and consider alternatives for repair and replacement options.

power plants. SwRI will develop, construct and evaluate an onsite full-scale compression/pumping pilot plant to demonstrate this efficient compression technology (machinery.swri.org).

The safety and performance of deep ocean equipment used in offshore petroleum production and transmission remain a high priority (deepoceansimulation.swri.org). To address high-temperature, high-pressure oil and gas environments, we initiated three joint industry programs to conduct corrosion-fatigue modeling of riser integrity, riser reeling and titanium riser stress joint qualification. We developed and implemented a new safety system, based on international standards in safety management systems, and developed a new blast-resistant subsurface well safety valve test facility.

Our program in aircraft structures continues to help ensure the structural integrity of military and commercial aircraft. In 2011, we completed the full-scale fatigue testing program for the first commercial "very light jet" on the market (aerospacestructures.swri.org).

Continuing decades of support to the nuclear industry, we released the fourth generation of our EDAS® ultrasonic data acquisition and analysis system hardware, EDAS-IV. These systems support the inspection of nuclear reactor pressure vessel and piping welds, and the first system delivered successfully performed an in-service inspection in 2011. This latest version is half the size and weight of the previous generation, allowing the system to be easily transported to different areas of the plant (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.

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

D018123_0175

In 2011, we completed the fabrication of the pressure sphere for a deep ocean scientific research submersible. As one of the few companies with current experience designing pressure vessels for human occupancy to meet both U.S. Navy and ABS regulations, SwRI led the design and fabrication of the titanium diving hull, built to withstand depths up to 6,500 meters, allowing access to 99 percent of the ocean floor.

D018142_0699

A newly developed magnetostrictive transducer collar can produce long-range guided waves in buried pipe to inspect pipeline integrity from a single sensor position. This new MsT technology can be deployed using SwRI's portable MsSR® 3030R package to generate the waves and collect data (ndesensors.swri.org).

Space Science and Engineering

Southwest Research Institute has emerged during the past three decades as one of the nation's leading centers for basic space science research and the development of spacecraft instrumentation and avionics systems. Our space research activities fall principally within two areas, space plasma physics and planetary science, and involve observational as well as theory and modeling programs.

The SwRI-led Juno mission to Jupiter, launched in August, addresses both space physics and planetary science goals. Two Institute-built instruments — the Jovian Auroral Distributions Experiment and the Ultraviolet Spectrograph — will study Jupiter's powerful aurora and investigate the magnetic-field-aligned electric currents that flow between the ionosphere and the magnetosphere. Other Juno experiments will probe Jupiter's atmosphere and interior, seeking information about the giant planet's internal structure and composition as well as clues to its formation in the solar nebula 4.5 billion years ago.

JADE and UVS are two of several SwRI-developed instruments currently flying or under development for flight on upcoming missions. Ultraviolet spectrographs similar to UVS on Juno are flying on the European Space Agency's Rosetta comet mission and NASA's New Horizons mission to Pluto, which will encounter their targets in 2014 and 2015, respectively, as well as on the Lunar Reconnaissance Orbiter, now in orbit around the Moon. Both Rosetta and New Horizons are also equipped with SwRI-built plasma instruments.

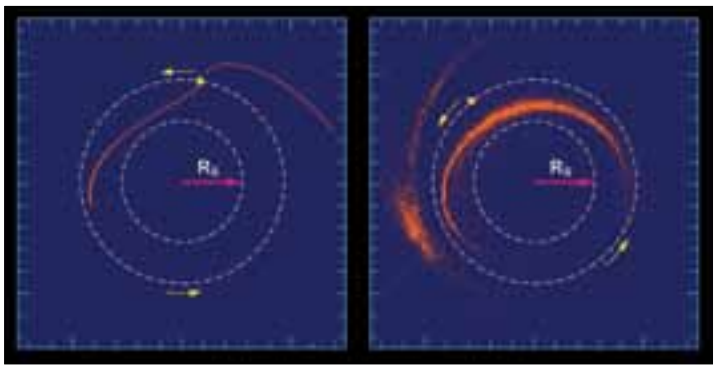
Four Hot Plasma Composition Analyzers for NASA's Magnetospheric Multiscale mission and the Strofio mass spectrometer for ESA's BepiColombo mission to Mercury are now being built. Both missions are scheduled to launch in 2014. SwRI is the principal investigator institution for the Heavy Ion Sensor flying on ESA's Solar Orbiter (launch 2017) and was recently selected by NASA to receive technology development funding for the ultra-sensitive, high-resolution Mass Spectrometer for Planetary Exploration, which promises to significantly advance capabilities to measure the composition of cometary comas and planetary atmospheres. Also under development is a miniaturized Laser Desorption Resonance Ionization Mass Spectrometer, which will enable highly accurate *in-situ* geochronology measurements on the Moon and Mars.

Earth and the other planets are immersed in the solar wind, the continuous outflow of magnetized plasma from the Sun. Institute scientists, together with colleagues at the National Solar Observatory, have developed novel image processing techniques to extract extremely faint signals against

D018190_6350

MASPEX is a next-generation multibounce time-of-flight mass spectrometer being developed for future planetary missions. The SwRI team is exploring a number of Earth-based spin-off applications of this novel technology as well.

D018217



A new theory by SwRI scientists proposes that Saturn's rings were created from ice stripped by planetary tides from the outer ice layers of a Titan-sized moon migrating inward toward Saturn — and eventually crashing into the planet. The frames above show a simulation of this process after (left) 8 simulated hours and (right) 25 simulated hours for a satellite orbit indicated by the outer dashed circle. Orange particles represent ice stripped from the satellite, while the inner dashed circle indicates Saturn's current mean radius.

the brilliant stellar background, making it possible for the first time to image and track large-scale solar wind density structures as they propagate from the Sun to Earth.

Researchers are analyzing the latest sky maps from the SwRI-led Interstellar Boundary Explorer and discovering an even more mysterious interaction between the solar wind and local interstellar medium — one that is defined by the interstellar magnetic field and evolves over time. The IBEX team also discovered a new orbit expected to be stable for decades and maneuvered the spacecraft into that orbit, extending the mission and opportunity for deeper understanding and new discoveries for many years to come.

Our spacecraft avionics program has grown extensively and expanded into key new technical areas, including the successful flight of SwRI control avionics on NASA's Robotic Lander Test Bed, development of a very high performance single-board computer tailored for the challenging space environment, and delivery of advanced memory storage products for NASA and commercial clients (spaceavionics.swri.org). The Defense Advanced Research Projects Agency recently selected SwRI to provide engineering models for the communication subsystem for DARPA's System F6 "fractionated" spacecraft architecture program. ❖

◆ *spacecraft instrument systems* ◆ *spacecraft avionics systems design*
◆ *spacecraft computer development* ◆ *solar & heliospheric physics*
◆ *spacecraft support systems & software* ◆ *planetary science*
◆ *data analysis & science support* ◆ *power systems design*
◆ *theoretical & observational studies* ◆ *space plasma physics*

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

D018216

Courtesy NASA/MSFC

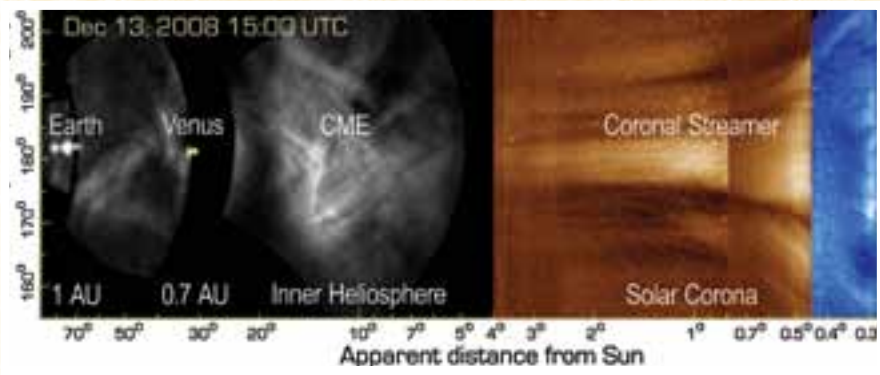
Controlled by an SwRI-developed avionics subsystem, NASA's robotic lander prototype performed a successful free-flight test in June 2011. NASA is developing such landers for the future exploration of the Moon and other airless solar system bodies such as asteroids.

Courtesy NASA/JPL

D018215

This artist's concept illustrates the Juno spacecraft after its arrival at Jupiter in 2016. Equipped with nine science instruments, including two developed at SwRI, Juno will be the first mission to study the planet from a polar orbit.

D018237



Using data from NASA's STEREO spacecraft, researchers at SwRI and the National Solar Observatory have developed the first detailed images of solar wind structures, including a coronal mass ejection, propagating from the solar corona toward Venus and Earth. Fast earthward-directed CMEs are responsible for space weather disturbances, which can disrupt the transmission of electrical power on Earth as well as the operation of communications and navigation satellites.

Geosciences and Engineering

For almost 25 years, Southwest Research Institute has been building and operating a center of excellence in geosciences and engineering, initially applying this expertise to long-term radioactive waste storage and disposal before expanding our research to encompass the entire nuclear energy cycle as well as oil and gas, water resource and planetary science programs.

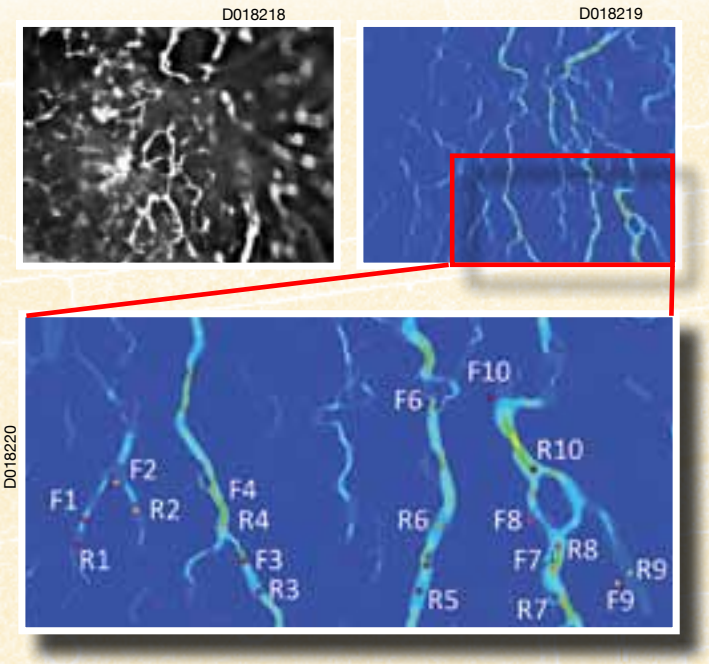
We continue operating the Center for Nuclear Waste Regulatory Analyses, closing out the discontinued Yucca Mountain, Nev., high-level radioactive waste repository project in 2011. We compiled a comprehensive technical evaluation and dozens of additional reports to summarize and document for future use the vast knowledge base associated with nearly 25 years of research and technical assistance associated with the project (cnwraweb.swri.org).

The CNWRA® contributed to seven evaluations of potential environmental impacts and mitigating measures associated with various uranium recovery, food irradiation and nuclear fuel fabrication operations, as well as one new nuclear power plant license application. We supported on-site inspections and reviewed the aging management and quality assurance programs of 10 existing nuclear power plants to assess their operational safety for the next 20 years (environmentalimpact.swri.org).

We continue to lend our expertise beyond U.S. borders, developing pre-closure safety assessment software and a model to analyze a potential deep geological repository for radioactive waste for international clients. We also conducted our first environmental assessment in Mexico, addressing air emissions, water discharge and waste management for an industrial facility.

SwRI has expanded capabilities to support groundwater management to include surface water considerations such as flooding hazard evaluations and dam spillway and river bed analyses. Next-generation designs of our award-winning neutrally buoyant sensor provide a robust, low-cost, relatively small sensor that uses ultrasonics to measure conduits ranging from caves to pipes. For example, we demonstrated that it accurately images the interior of pipes varying in size from less than a foot to greater than 10 feet in diameter to detect dents in corrugated piping or defects in culverts that can compromise their structural integrity and lead to potentially disastrous failures. The latest-generation sensor isolates all electronics in a compact vessel less than three inches in diameter and less than one foot in length and can image flaws and defects in pipes, sewers and culverts hundreds or thousands of feet long that are inaccessible by conventional inspection methodologies (hydrology.swri.org).

To support oil and gas exploration and development, we characterize potential reservoirs using a full range of analytical and geological techniques. We continue adding petroleum



SwRI scientists applied new physically based modeling techniques to simulate trajectories and retention of submicron-sized particles traveling in biological tissue. The top-left image shows blood vessels across an ovarian tumor, and the top-right image shows the computed steady-state flow field of the vessels. The bottom image displays the release (R) location and final (F) destination of particles.

For the Nuclear Regulatory Commission, scientists conducted large-scale experiments to physically model and evaluate the performance of grout proposed to stabilize legacy radioactive wastes in tanks at nuclear material production facilities. Fissures in the grout are evaluated as potential pathways for radionuclide movement and release.

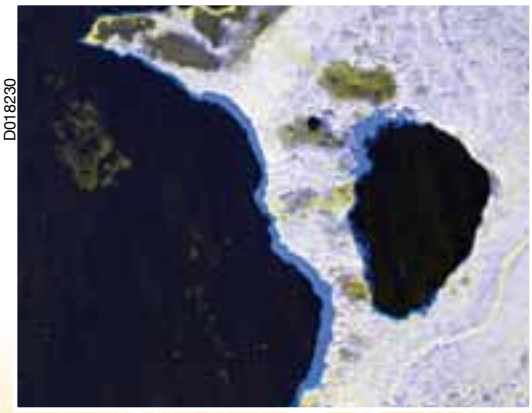
◆ ***geophysical & geological investigations*** ◆ ***groundwater resource evaluations*** ◆ ***geological structure analyses*** ◆ ***energy exploration*** ◆ ***chemical & radiological contaminant transport*** ◆ ***laboratory, field & numerical analyses*** ◆ ***corrosion & materials life prediction*** ◆ ***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***

exploration courses that are offered to the industry through a third-party courseware vendor, helping participants learn to recognize geological structures and features that indicate oil and gas potential (geoscience.swri.org).

We transfer our extensive earth sciences expertise to study surface features on Mars and other planetary bodies. Pit crater chains, common planetary topographic features, originate from a wide range of mechanisms, but by studying analogous features on the coast of Iceland and comparing them to high-resolution imagery on Mars, SwRI scientists conclude that similar processes — such as extensional fracturing and dilational normal faulting — are the most probable mechanisms on Mars (planetarygeo.swri.org). ❖

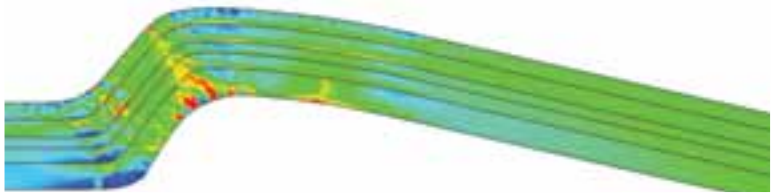
Visit geosciences-engineering.swri.org for more information or contact Vice President Dr. Wesley Patrick at (210) 522-5158 or wesley.patrick@swri.org.

D018230



Through an Earth Observation Systems Research Initiative, SwRI developed radar and optical techniques to investigate thawing of permafrost in arctic environments and measure sea ice properties in the Antarctic. SwRI scientists developed high-resolution co-registration techniques to investigate long-term changes in permafrost, comparing aerial photographs from 1951 with more recent satellite imagery. The blue areas indicate where the thermokarst lakes have expanded due to permafrost thawing since 1951.

D018227

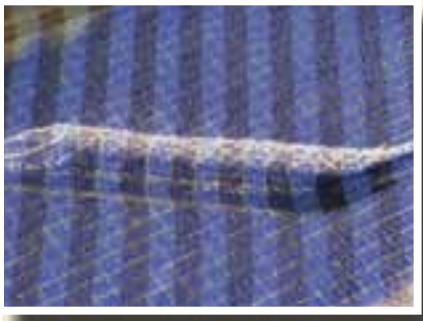


D018228

Using integrated field and numerical geomechanical modeling, SwRI studied an outcrop analog of a sandstone oil reservoir in central Wyoming. We combined rock mechanics and hardness data with outcrop fracture measurements to develop nonlinear finite element models, where different colors indicate variations in modeled stress.

D018147_1159

D018147_1162



SwRI upgraded its structural geology analog laboratory and developed a portable analog modeling apparatus to support ongoing research in seismic hazard assessment and petroleum exploration. Improvements include installing vibration-proof framing to support higher-resolution digital terrain data collection (analogmodel.swri.org).

Signal Exploitation and Geolocation

As today's communications spectrum becomes increasingly complex, Southwest Research Institute continues its development of innovative solutions for U.S. and friendly foreign governments that expand the performance of traditional communication signal intercept, direction finding, surveillance, tracking and geolocation technologies.

To help reduce friendly fire incidents on the battlefield, engineers continue co-developing the Flashlight™ Soldier Combat Identification System. Comparable in concept to an ordinary flashlight, an interrogator focuses radio beams, "illuminating" the area in its path. Soldiers and other assets fitted with a transponder are identified, alerting the soldier with the interrogator to the presence of friendly forces (sgd.swri.org). The U.S. Office of the Secretary of Defense recently gave FSCIS high marks in an evaluation.

We created, documented and released a new technical data interchange that allows government agencies to task, report and disseminate information processed by the worldwide geolocation network. The upgrade is the first major redesign of the network in almost 30 years, significantly expanding data formats, structures and data storage, as well as supporting future expansion requirements.

Our engineers are developing an integrated mast antenna and ruggedized below-deck equipment using SwRI's Frontier architecture for shipboard applications (tpd.swri.org). We also are expanding Frontier's capabilities to provide a cost-effective solution for high priority SIGINT applications within the U.S. and allied navies.

Our Skywisp® atmospheric glider lifts a wide range of mission payloads to stratospheric altitudes. We recently fitted the Skywisp glider with capillary tubing to measure greenhouse gas concentrations from sea level to 100,000 feet. The tubing self-evacuates as it ascends and collects ionospheric gases as it descends. The samples are compressed in layers that roughly correspond to the collection heights, providing an efficient, cost-effective method for analyzing carbon dioxide, methane or other gases compared to the use of high-altitude aircraft and free-floating balloons.

In response to client needs, we are developing methods to incorporate diverse geolocation operational data into the computing "cloud" and designing efficient methods to store and retrieve the information (sed.swri.org).

We also are building on our N-channel technology expertise in high-frequency bandwidths, applying this expertise to the U.S. government's next-generation VHF/UHF communications intelligence sensors.

For another program, we are developing advanced capabilities for a flexible radio frequency communication platform using software-defined radio technology for operationally

D017937_0227

Our engineers are reducing the size, weight and power consumption of the Flashlight™ Soldier Combat Identification System to make the system "soldier-scale." The system also could be scaled up for use on ground vehicles and aircraft, replacing the array of combat identification systems currently in use.

D018224

An SwRI researcher holds the Skywisp® glider prior to in situ *gas collection. Capillaries are visible on the underside of the wings. The glider can be launched with a weather balloon to altitudes as high as 100,000 feet and its descent controlled to a specified GPS coordinate.*

responsive space plug-and-play compatibility (se.swri.org).

SwRI uses internal research funds to help develop these technologies and pave the way for client-sponsored programs. We continue to use internal funding to reduce the size, weight and power of electronic systems and components. These reductions have contributed to the success of our combat identification and unmanned aerial vehicles.

analysis, analytics & reporting • antennas & propagation • array processing • cloud computing • combat identification • communications signal processing • communications solutions • cross domain solutions • cyber exploitation • combat identification • electromagnetic modeling • electronic attack • electronic warfare • genetic programming • intelligence networking • GPS engineering • high-performance data visualization • information exploitation • information operations • geolocation • SEI CMMI®-DEV Level 3 • life-cycle support • micro-SIGINT • signals intelligence • steganalysis • surveillance systems • tagging, tracking & locating solutions

Staff members perform signal exploitation and geolocation projects according to the ISO 9001 Quality Management System. Since 2008, our "Business Environment for Effective Management" has provided a business system that satisfies both ISO 9001 and the Software Engineering Institute's Capability Maturity Model® Integration, which was appraised at Level 3 in October. This combination helps assure strict quality standards are met for products and services, as well as for process improvement and program efficiency and effectiveness. ❖

Visit sigint.swri.org for more information or contact Vice President Dr. William G. Guion at (210) 522-2902 or william.guion@swri.org.

D018229

Courtesy DOD Australia

D018213

SwRI designed an integrated mast antenna (inset) for installation on Australian AWD-class ships. SwRI SIGINT capabilities support allied navies throughout the world.

D017989_3110

SwRI maintains a 200-acre field test site to assess the performance of various antenna designs. We are updating the measurement equipment at the site, including adding new arrays and fiber optic links with distant laboratories to improve the efficiency and cost effectiveness of client programs.

Applied Physics

With a diverse staff and a wide range of engineering facilities and expertise, Southwest Research Institute creates sophisticated, miniaturized, low-power electronic, sensor and optical systems and devices for a range of applications. We also evaluate novel robot systems and develop new algorithms and software programs to collect and process data.

With funding from the Department of Homeland Security, SwRI is developing a next-generation mobile biometrics optical fingerprint reader to provide a lightweight, compact, rugged system for 4-slap and faster 10-print capture in field applications. At less than one-third the weight and volume of conventional non-mobile systems, our fingerprint reader uses novel microprism technology combined with a compact image sensor array and variable focus liquid lenses to eliminate the heavy glass prisms and large optics used in existing 4-slap and 10-print capture devices. The fingerprint reader includes onboard processors to interface with existing laptop computers and the SwRI-developed SIIMON mobile biometrics capture device or to support future stand-alone applications by law enforcement, the military, border agents and first responders (biometrics.swri.org).

SwRI scientists are collaborating with The University of Texas at San Antonio to create wire array "hyperlenses" for biomedical infrared imaging of live tissue at a level of detail not possible with conventional techniques. SwRI developed the computational modeling necessary to validate the design while UTSA scientists developed the fabrication scheme to demonstrate the proposed hyperlenses, which are composed of metamaterials or engineered composites. The unique properties of metamaterials arise from carefully shaping and positioning small structures in a host material — in this case, nanoscopic metal wires in alumina (advancedelectronics.swri.org).

SwRI engineers are developing spherically configured laser sensors for use in high-performance, large-scale 3-D metrology systems. The technology enables large-scale mobile robotics, which use triangulation of intersecting laser beams to make precise measurements of object positions within a large workspace, such as an airplane hangar or a factory production floor. SwRI

D018173_4250

SwRI developed this compact fingerprint capture sensor for mobile biometrics applications; our system is less than one-third the weight and volume of conventional systems.

Courtesy Gill Pratt

D018225

Our engineers are studying the hazards associated with deploying small unmanned air vehicles in U.S. airspace to potentially allow use in law enforcement operations, search and rescue scenarios, and building and bridge inspections.

D018226

To support a DARPA program, SwRI engineers evaluated this robot's advanced walking gait as it traversed a sand dune.

used internal research funds to create two prototypes that improve on the state of the art by significantly increasing sensor field of view, providing notch filtering and shielding to reduce optical and electromagnetic noise, and using low-cost components that would reduce the overall sensor cost by an order of magnitude or more.

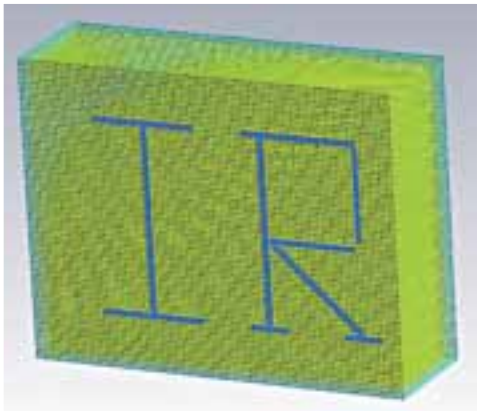
In a project for the Office of Naval Research supported by Texas Tech University, we demonstrated the feasibility of a portable 3-D X-ray imaging system to probe the internal composition of improvised explosive devices. The system uses a pivot arm apparatus that sweeps through a range of angles to collect multiple 2-D images, which are then processed using back-projection algorithms to map out the internal IED components. This technology supports tactical explosive ordnance disposal robots.

As part of our small robot evaluation program, SwRI is working with the National Institute of Standards and Technology to identify and quantify hazards associated with small unmanned air vehicles falling out of the sky to develop a safety standard for deploying UAVs in U.S. airspace. Once the standard is accepted by the Federal Aviation Administration, UAVs could be used in a variety of applications, including law enforcement operations, search and rescue scenarios, and building and bridge inspections. ❖

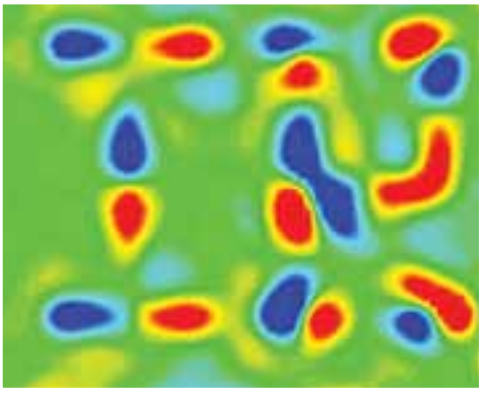
Visit applied-physics.swri.org for more information or contact Vice President Ed Moore at (210) 522-2739 or ed.moore@swri.org.

◆ 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

D018235



D018240



Institute scientists developed 3-D numerical models for a "hyperlens" designed to allow bimolecular researchers to watch events such as a neuron firing. The letters "IR" in the modeled structure (top) are the image source, visible below as electric field strength exiting the slab at the imaging plane. Resolution is about 900 nanometers at 30 terahertz — more than five times higher than possible with a conventional lens.

D018163_2438

Staff members developed prototype spherically configured laser sensors to dramatically improve the performance and reduce the cost of position sensors used in a 3-D laser metrology system. The spherical sensor design is sensitive to laser light over a significantly wider range of angles than conventional cylindrical designs.

Chemistry and Chemical Engineering

Southwest Research Institute develops advanced chemistry and chemical engineering solutions to meet global challenges in areas ranging from alternative energy to pharmaceutical development to fire technology. Working with industrial and governmental clients, we also address environmental threats, food safety and homeland security concerns.

Our chemists are investigating various alternatives to imported petroleum for liquid transportation fuels, including natural gas, tar sands, oilseed crops and algae. SwRI's hydrocarbon processing laboratory is developing a continuous supercritical methanol process to efficiently convert triglycerides into biodiesel. A simplified product purification process requires less energy, is not water-sensitive, and requires shorter processing times than comparable processes (chemeng.swri.org).

Medicinal chemistry and drug formulation capabilities continue to expand with a focus on microencapsulation and nanomaterials (microencapsulation.swri.org). SwRI scientists are investigating new formulations to expand the delivery of cholesterol-lowering statins to potentially treat an array of medical conditions and are developing conventional and novel antidotes for protection against chemical weapons. These collaborative programs leverage enhanced tools for molecular modeling, docking studies, property analysis, compound design, synthesis and biological screening (synchemistry.swri.org).

Working with the U.S. Department of Health and Human Services, SwRI is developing a nasal delivery formulation for an amyl nitrite countermeasure to cyanide poisoning. The goal is to develop a formulation with a long shelf life and then conduct safety and efficacy studies required for Food and Drug Administration approval. A nasal formulation could be self-administered rather than injected by qualified medical personnel, potentially saving lives by allowing a metered dose to be administered to large numbers of casualties quickly and effectively in the field.

SwRI's high efficiency particulate air-filtered, Current Good Manufacturing Practice-compliant, high-bay facility produces clinical trial supplies of controlled-release products, including abuse-resistant pain medications and biodegradable, sustained-release injectable products for Phase 1 clinical trials (drugdelivery.swri.org).

We develop new analytical techniques to quickly and cost-effectively screen for contamination of foods, materials, water and geological materials, as well as to assess their

D018049_9284

We design and operate laboratory-, pilot- and demonstration-scale systems to advance novel gas-to-liquids and heavy-oil upgrading techniques to turn previously impractical petroleum reserves into viable resources. Our research is aimed at making it commercially advantageous to harvest natural gas reserves that are difficult to produce due to geography, size or composition.

D018234

The Institute operates a mobile, automatic, continuous air-monitoring system to provide early detection of chemical warfare agents in support of carbon filter unit decommissioning at the Pine Bluff Chemical Agent Disposal Facility in Arkansas.

purity. Our radiochemistry laboratory can identify and quantify more than 400 isotopes from mixed waste and other samples (environmentalchemistry.swri.org).

SwRI fire engineers have expanded their support for the nuclear power industry, creating large-scale test equipment to analyze how electric cables respond to high radiant heat exposure. Numerous properties are measured, including the cables' propensity to ignite, produce smoke and release heat as well as the dielectric breakdown of cable insulation (fire.swri.org).

For more than 25 years, we have played a major role in the safe destruction of chemical warfare agents at U.S. stockpile sites at Johnston Atoll; Newport, Ind.; Pine Bluff, Ark.; and Umatilla, Ore. During destruction operations, SwRI's on-site laboratories collected and analyzed millions of air and other samples to assure the safety of workers, the public and the environment. We are now supporting cleanup activities at the Pine Bluff and Umatilla plants to verify site remediation for future government or community uses. ❖

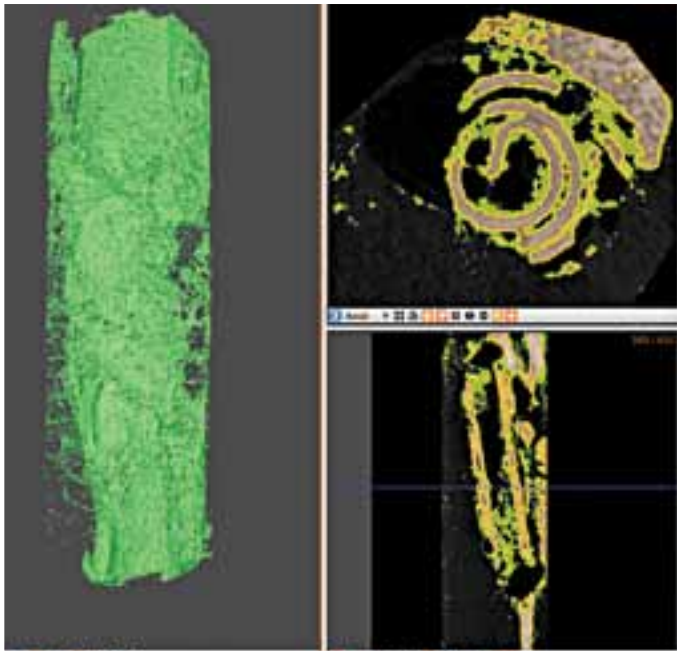
Visit chemistry.swri.org for more information or contact Vice President Dr. Michael MacNaughton at (210) 522-5162 or michael.macnaughton@swri.org.

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

D018233

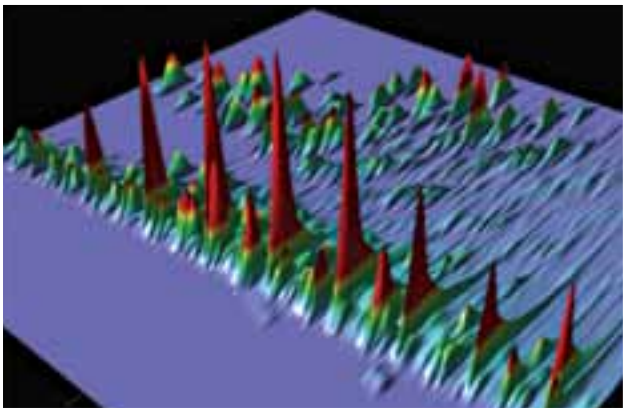
To support the nuclear power industry, SwRI built this apparatus to expose test samples to fixed amounts of radiant energy. We measure the heat release rate and amount of smoke produced to understand how components such as electrical cables perform when exposed to intense heat rather than direct flames.

D018211



Scientists continue developing novel scaffolds to improve and accelerate wound healing, as demonstrated by the bone-like tissue shown growing in and around (at right) this magnesium scaffold implant (biomedical.swri.org).

D018231



Analytical chemists are searching for chemical signatures associated with diabetes and cardiovascular disease in breath, blood, urine and other biological samples using advanced high-resolution, two-dimensional gas chromatography coupled with time-of-flight mass spectrometry. Identifying these metabolic biomarkers could support the development of inexpensive diagnostic testing techniques.

Consolidated Financial Statements

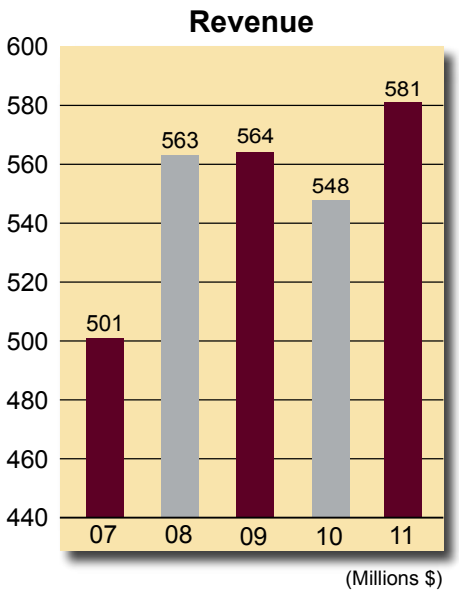
For the years ended September 30, 2011, and September 24, 2010

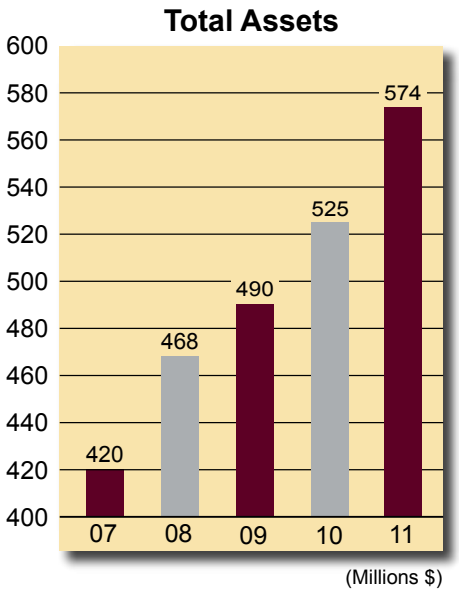
Income Statements (in thousands of dollars)

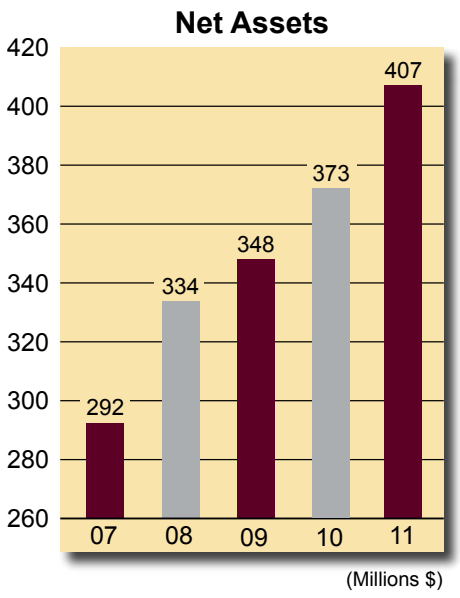
	2011	2010
Revenue	$581,385	$547,922
Direct Project Costs	347,446	324,157
Operating Income	233,939	223,765
Division Operating Expenses	126,687	125,382
General Overhead	56,853	49,772
Depreciation — General Facilities	14,808	13,894
Internal Research	6,123	6,732
Realized/Unrealized Loss (Gain) on Postretirement Medical Funds	725	(2,463)
Income Before Federal Income Tax Expense	28,743	30,448
Federal Income Tax Expense	(352)	(1,046)
Net Income	$28,391	$29,402

Balance Sheets (in thousands of dollars)

	2011	2010
Current Assets	$243,969	$205,887
Property and Equipment, Net	263,439	257,246
Other Assets	66,213	61,405
Total Assets	$573,621	$524,538
Current Liabilities	$99,332	$80,192
Noncurrent Liabilities	67,560	71,663
Net Assets	406,729	372,683
Total Liabilities and Net Assets	$573,621	$524,538







Board of Directors

Chairman
Mr. John C. Korbell
Managing Director — Wealth Management
Senior Investment Management Consultant
Morgan Stanley Smith Barney
San Antonio, Texas

Vice Chairman
Mr. Philip J. Pfeiffer
Senior Partner (Retired)
Fulbright & Jaworski L.L.P.
San Antonio, Texas

Mr. Wayne S. Alexander
President (Retired)
SBC Southwestern Bell
San Antonio, Texas

Mr. Eugene L. Ames Jr.
Petroleum Geologist
San Antonio, Texas

Mr. J. Dan Bates
President
Southwest Research Institute
San Antonio, Texas

Mr. Richard W. Calvert
San Antonio, Texas

Mr. Walter D. Downing
Executive Vice President
Southwest Research Institute
San Antonio, Texas

Mr. A. Baker Duncan
Chairman
Duncan-Smith Investments Inc.
San Antonio, Texas

Mr. Roger R. Hemminghaus
Chairman and CEO (Retired)
Ultramar Diamond Shamrock Corporation
San Antonio, Texas

Mr. Milton B. Lee
General Manager and CEO (Retired)
CPS Energy
San Antonio, Texas

Dr. Mary Ann Rankin
CEO
National Math & Science Initiative
Dallas, Texas

Mr. John B. Roberts
Chairman of the Board and President (Retired)
Busch Entertainment Corporation
Austin, Texas

Dr. Ricardo Romo
President
The University of Texas at San Antonio
San Antonio, Texas

Mr. Curtis Vaughan Jr.
Chairman of the Board
Vaughan & Sons Inc.
San Antonio, Texas

Mr. David S. Zachry
President and CEO
Zachry Corporation
San Antonio, Texas

Officers

President, Mr. J. Dan Bates

Executive Vice President, Mr. Walter D. Downing

Chief Financial Officer, Vice President — Finance, and Institute Secretary, Mrs. Beth Ann Rafferty

Treasurer and Assistant Institute Secretary, Mr. J.S. Fernandi

Vice Presidents

Aerospace Electronics, Systems Engineering and Training
Mr. Richard D. Somers, Vice President

Applied Physics
Mr. Ed Moore, Vice President

Applied Power
Mr. Bob Keys, Vice President

Automation and Data Systems
Mrs. Susan B. Crumrine, Vice President

Chemistry and Chemical Engineering
Dr. Michael G. MacNaughton, Vice President

Engine, Emissions and Vehicle Research
Mr. Bruce B. Bykowski, Vice President

Fuels and Lubricants Research
Mr. Lee J. Grant, Vice President

Geosciences and Engineering
Dr. Wesley C. Patrick, Vice President

Mechanical Engineering
Mr. Danny M. Deffenbaugh, Vice President

Signal Exploitation and Geolocation
Dr. William G. Guion, Vice President

Space Science and Engineering
Dr. James L. Burch, Vice President

Facilities and General Services
Mr. Pat Griffith, Vice President

Institute Environmental, Safety and Quality Systems
Dr. Amos E. Holt, Vice President

Legal and Patent Office
Mr. John W. McLeod, Vice President and General Counsel

Special Programs
Dr. Katharine C. Golas, Vice President

Advisory Trustees

Mr. James "Jim" R. Adams
Chairman of the Board (Retired)
Texas Instruments
San Antonio, Texas

Dr. C. Mauli Agrawal
Dean, College of Engineering
The University of Texas at San Antonio
San Antonio, Texas

Dr. Dennis A. Ahlburg
President
Trinity University
San Antonio, Texas

Mr. Jack R. Allender
Partner
Fulbright & Jaworski L.L.P.
Houston, Texas

Mr. Curtis "Curt" V. Anastasio
President and CEO
NuStar Energy L.P.
San Antonio, Texas

Mr. Henry "Hank" Arendt, P.E.
Director of Technology (Retired)
Halliburton Energy Services
Dallas, Texas

Mr. Kenneth "Ken" E. Arnold, P.E., N.A.E.
Senior Technical Advisor
WorleyParsons
Houston, Texas

Mr. James R. Berg
President
Matson Creative.com
San Antonio, Texas

Mr. Glenn E. Biggs
Chairman
Texas Heritage Bank
Boerne, Texas

Dr. John R. Brazil
President Emeritus
Trinity University
Boerne, Texas

Mrs. Phyllis Browning
Chairman and CEO
The Phyllis Browning Company
San Antonio, Texas

Mr. J. Fred Bucy Jr.
President and CEO (Retired)
Texas Instruments Inc.
Dallas, Texas

Mr. Richard "Dick" L. Burdick
CEO (Retired)
Thermon Industries Inc.
New Braunfels, Texas

Mr. Michael D. Burke
Chair and Founder
San Antonio Clean Technology Forum
San Antonio, Texas

Dr. Ronald K. Calgaard
Chairman and Trustee
Ray Ellison Grandchildren Trust
San Antonio, Texas

Mr. Trent Campbell Jr.
President
Campbell Industrial Sales Inc.
Houston, Texas

Dr. Donald M. Carlton
CEO (Retired)
Radian International
Austin, Texas

Dr. Francisco G. Cigarroa
Chancellor
The University of Texas System
Austin, Texas

Ms. Lila M. Cockrell
President
San Antonio Parks Foundation
San Antonio, Texas

General Donald "Don" G. Cook,
USAF (Ret.)
San Antonio, Texas

Dr. Charles L. Cotrell
President
St. Mary's University
San Antonio, Texas

Dr. William "Bill" H. Cunningham
The University of Texas at Austin
Austin, Texas

Mr. Richard "Rich" B. Curtin
Executive Vice President —
Operations (Retired)
Southwest Research Institute
San Antonio, Texas

Dr. Roger Eichhorn
Professor Emeritus
University of Houston
Houston, Texas

Mr. John W. Feik
President and COO
DFB Pharmaceuticals Inc.
San Antonio, Texas

Dr. Gregory L. Fenves
Dean, Cockrell School of Engineering
The University of Texas at Austin
Austin, Texas

Dr. William "Bill" L. Fisher
Leonidas T. Barrow Centennial Chair
in Mineral Resources
Professor, Department of
Geological Sciences
Jackson School of Geosciences
The University of Texas at Austin
Austin, Texas

Dr. Peter T. Flawn
President Emeritus
The University of Texas at Austin
Austin, Texas

Dr. Raymond "Ray" W. Flumerfelt, P.E.
Professor of Chemical Engineering and
Deputy Director, NWERTC
University of Houston
Houston, Texas

Dr. Robert "Bob" R. Fossum
Senior Technical Officer
Estacur Inc.
Dallas, Texas

Mr. James B. Francis Jr.
President
Francis Enterprises Ltd.
Dallas, Texas

Mr. Tom C. Frost
Chairman Emeritus
Frost
San Antonio, Texas

Advisory Trustees

Mr. Martyn C. Glen
Managing Director
Integra Realty Resources — San Antonio
San Antonio, Texas

Dr. Earnest "Ernie" F. Gloyna
Professor, Bettie Margaret Smith Chair (Retired)
The University of Texas at Austin
Austin, Texas

Mr. Christopher "Kit" Goldsbury Jr.
President and CEO
Silver Ventures
San Antonio, Texas

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

Dr. Joseph "Jody" M. Grant
Chairman Emeritus — Texas Capital Bank
Partner and Senior Advisor — BankCap Partners
Dallas, Texas

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

Dr. Charles "Chip" G. Groat
Director, Center for International Energy and Environmental Policy (CIEEP)
Professor, Jackson School of Geosciences
The University of Texas at Austin
Austin, Texas

Mr. Mike Grubb
President and CEO
Southern Gas Association
Dallas, Texas

Dr. Rolf R. Haberecht
Chairman of the Board
VLSIP Technologies Inc.
Richardson, Texas

Mr. Richard Hageman
Senior Vice President (Retired)
Thermon Industries Inc.
Garden Ridge, Texas

Mr. John "Jack" A. Hammack
Hammack Oil Company
Dallas, Texas

Mr. Houston H. Harte
Vice Chairman
Harte-Hanks Inc.
San Antonio, Texas

Mr. George A. Helland Jr., P.E.
Senior Associate
IHS-Cambridge Energy Research Associates
Houston, Texas

Dr. William L. Henrich, MACP
President
The University of Texas Health Science Center at San Antonio
San Antonio, Texas

Mr. Mario Hernandez
President
San Antonio Economic Development Foundation
San Antonio, Texas

General Hal M. Hornburg, USAF (Ret.)
Owner
HMH Associates L.L.C.
Fair Oaks Ranch, Texas

Dr. John P. Howe III
President and CEO
Project HOPE
Millwood, Virginia

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

Dr. Anthony J. Infante
Professor of Pediatrics
The University of Texas Health Science Center at San Antonio
San Antonio, Texas

Mr. Mark M. Johnson
Regional Chairman
Texas Capital Bank
San Antonio, Texas

Mr. William "Bill" R. Klesse
CEO, President and Chairman
Valero Energy Corporation
San Antonio, Texas

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

Mr. Charles L. Korbell Jr.
President and CEO (Retired)
Clarke American
Fair Oaks Ranch, Texas

Mr. Joseph "Joe" R. Krier
Principal
The Krier Consulting Group
San Antonio, Texas

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

Mr. Julian G. Martin
Consultant
Austin, Texas

Mr. L. Lowry Mays
Chairman
Clear Channel Communications
San Antonio, Texas

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

Mr. Robert S. McClane
President
McClane Partners L.L.C.
San Antonio, Texas

Dr. Henry C. McGill Jr.
Senior Scientist Emeritus
Texas Biomedical Research Institute
San Antonio, Texas

Mr. John "Jack" K. Meyer
Proprietor
Fiduciary Services
San Antonio, Texas

Mr. Palmer Moe
Managing Director
Kronkosky Charitable Foundation
San Antonio, Texas

Advisory Trustees

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

Mr. Joe F. Moore
CEO (Retired)
Bonner & Moore Associates
Houston, Texas

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

Mr. Robert "Bob" G. Newman
Partner
Fulbright & Jaworski L.L.P.
San Antonio, Texas

Dr. John M. Niedzwecki
Head, Zachry Department of Civil Engineering
R.P. Gregory '32 Chair Professor
Texas A&M University
College Station, Texas

Dr. Geoffrey C. Orsak
Dean, SMU Lyle School of Engineering
Southern Methodist University
Dallas, Texas

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

Dr. David M. Pierce, P.E.
President
D.M. Pierce & Associates
Houston, Texas

Dr. Tessa Martinez Pollack
President
Our Lady of the Lake University
San Antonio, Texas

Mr. Chester N. Posey
Chairman
Orbix Corporation
Clifton, Texas

Dr. Carl F. Raba Jr., P.E.
Chairman and CEO
Raba-Kistner Consultants Inc.
San Antonio, Texas

Mr. Christopher T. Rice
Executive Vice President — Shared Services
AT&T Inc.
Dallas, Texas

Dr. Herbert "Herb" H. Richardson
Director Emeritus
Texas Transportation Institute
College Station, Texas

Mr. Phillip S. Sizer, P.E.
Consultant
Dallas, Texas

Mr. Jack M. Spinks
Owner
Spinks & Associates
Claremore, Oklahoma

Mr. Thomas A. Stephenson
President and Publisher
San Antonio Express-News
San Antonio, Texas

Mr. H. Leighton Steward
Chairman
Plants Need CO_2.org
Boerne, Texas

Dr. Ben G. Streetman
Professor Emeritus
The University of Texas at Austin
Austin, Texas

Mr. Timothy "Tim" N. Tipton
General Manager, Upstream Technology
Marathon Oil Company
Houston, Texas

Dr. Denise M. Trauth
President
Texas State University — San Marcos
San Marcos, Texas

Mr. Thomas L. Travis
President and CEO
International Bank of Commerce — Oklahoma
Oklahoma City, Oklahoma

Mr. Kenneth P. Trevett
President and CEO
Texas Biomedical Research Institute
San Antonio, Texas

Mr. Curtis T. Vaughan III
President and CEO
Vaughan & Sons Inc.
San Antonio, Texas

Mr. Edward E. Whitacre Jr.
Chairman of the Board and CEO (Retired)
General Motors Company
Chairman Emeritus
AT&T Inc.
San Antonio, Texas

Colonel Clarence R. "Reggie" Williams, USAF (Ret.)
President and CEO
San Antonio Area Foundation
San Antonio, Texas

Mr. John "Jack" H. Willome
President (Retired)
Rayco
Boerne, Texas

The Honorable Nelson W. Wolff
Bexar County Judge
Commissioners Court
San Antonio, Texas

Mr. Gary V. Woods
President
McCombs Enterprises
San Antonio, Texas

Mrs. Jeanie R. Wyatt, CFA
CEO and Chief Investment Officer
South Texas Money Management Ltd.
San Antonio, Texas

Mr. H. Bartell Zachry Jr.
President
Zachry Interests Inc.
San Antonio, Texas

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

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

Business Development • Southwest Research Institute
6220 Culebra Road • P.O. Drawer 28510
San Antonio, Texas 78228-0510 • (210) 522-2122 • Fax (210) 522-3496
bd@swri.org • swri.org