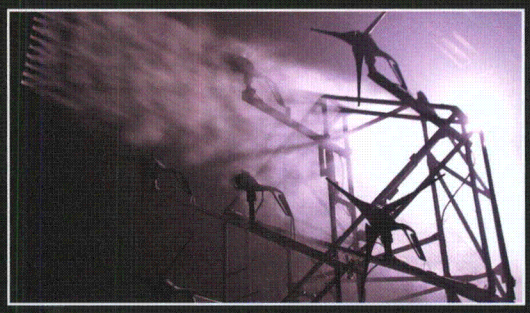
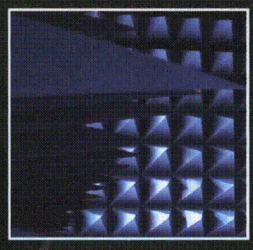
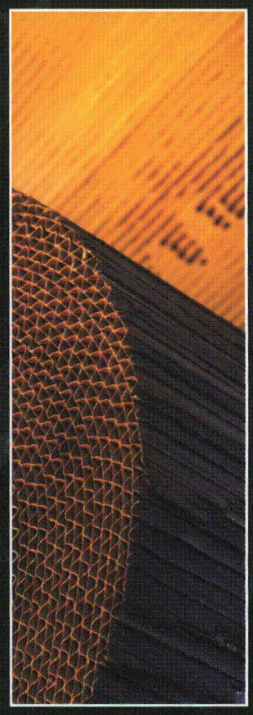
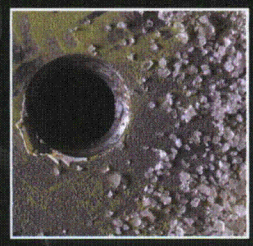
Southwest Research Institute®

Annual Report





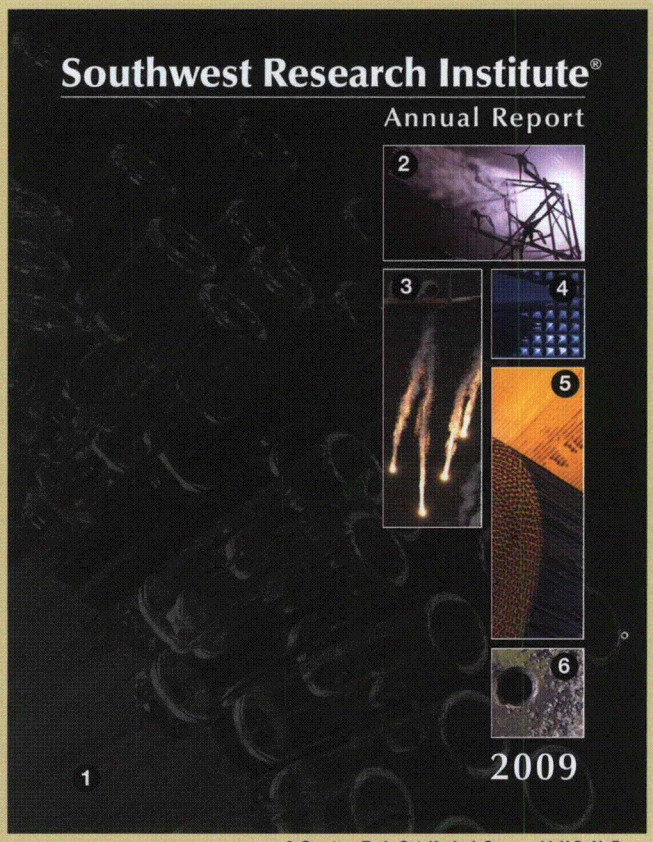




2009

Southwest Research Institute®

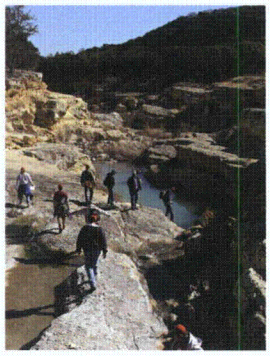
Benefiting government, industry and the public through innovative science and technology

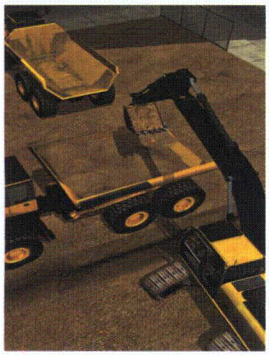


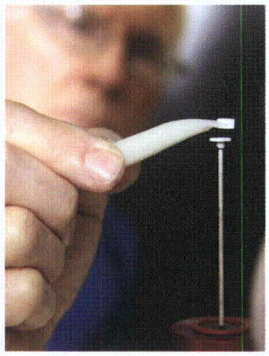
3. Courtesy Tech. Sgt. Kevin J. Gruenwald, U.S. Air Force

1. *Test tubes used for fuel sampling to ensure industry compliance.* **2.** *Smoke streams in wind tunnel for visualizing air flow from wind turbine arrays.* **3.** *A-10 Thunderbolt dispensing flares.* **4.** *Radio frequency anechoic chamber for validating system performance and optimizing designs.* **5.** *Ceramic particulate traps for controlling diesel engine emissions.* **6.** *Grains of cornstarch-based blast media for removing aircraft coatings.*

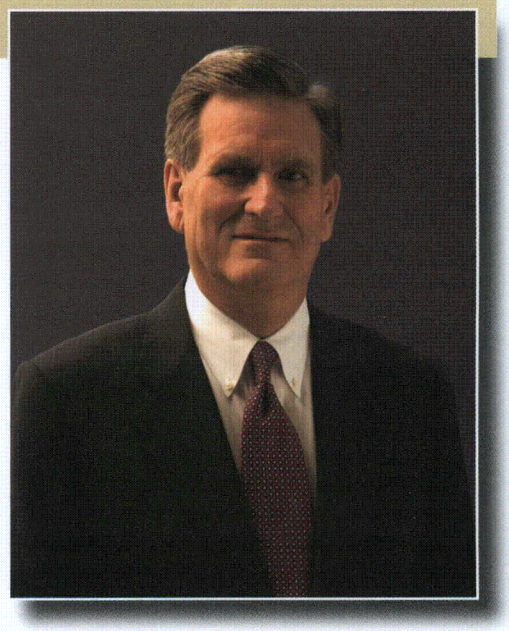
Contents







Message from the President



Despite fluctuations in the global economy during fiscal year 2009, Southwest Research Institute maintained a solid financial footing while responding to the technical challenges faced by our clients in industry and government. It gives me great pleasure to present this annual report highlighting just a portion of our programs and achievements throughout the year.

SwRI engineers demonstrated an autonomous vehicle in both urban and military simulated arenas. In New York City they demonstrated how an autonomous vehicle can cooperate with a human-driven vehicle using dedicated short-range communications. As part of our commitment to assisting national defense efforts, SwRI engineers successfully demonstrated field platooning capabilities of the vehicles as part of innovative unmanned ground systems technologies geared to military needs. The Institute's training and simulation staff expanded development of heavy equipment simulators for commercial and military applications.

Our world-class space physics and planetary science group experienced a year of notable accomplishments. The SwRI-designed and -built Lyman alpha mapping instrument was part of the science payload aboard NASA's Lunar Reconnaissance Orbiter, which detected water on the Moon. Meanwhile, as the Interstellar Boundary Explorer (IBEX) spacecraft was sending breakthrough images of the edge of the heliosphere back to Earth, the planetarium show, "IBEX: Search for the Edge of the Solar System," was presented to audiences around the world as part of the mission's educational outreach effort. The imaging coronal spectrograph, SPICE (Spectral Imaging of the Coronal Environment), was selected for the European Space Agency's Solar Orbiter mission to explore the innermost regions of the solar system from the closest distances to the Sun ever attempted.

We continue innovative programs to help mitigate environmental pollution and optimize existing technologies through client- and Institute-backed research and development programs. We launched the second High-Efficiency Dilute Gasoline Engine (HEDGE II) consortium to expand the initial program aimed at developing a high-efficiency gasoline engine for both the light-duty and medium-duty engine markets.

The Institute maintained its leadership roles locally and nationally by joining with The University of Texas at San Antonio, CPS Energy and the San Antonio Water System to form the Energy Research Alliance of San Antonio to define and implement new and alternative strategies for the development of energy technology.

The area of applied power has seen tremendous expansion over the past few years, resulting in our decision to spin off that department into its own division in 2010. The new organization will focus on design, simulation, development and application of sensor systems and electro-optical/infrared technologies, as well as advancing the state of the art in electric power systems and power distribution networks.

Staff members received national professional recognition through peer-reviewed papers, presentations, patents and other professional endeavors. Dr. Amos Holt, vice president of Environmental, Safety and Quality Systems, began a one-year term as president of the American Society of Mechanical Engineers. Dr. Thomas Ryan, Institute engineer in the Engine, Emissions and Vehicle Research Division, concluded his tenure as president of the Society of Automotive Engineers. J. Kevin Brunner, staff engineer in the Fuels and Lubricants Research Division, received the Forest R. McFarland Award from the Society of Automotive Engineers. Dr. Roger Phillips, Institute scientist in the Space Science and Engineering Division, received the American Geophysical Union's Whipple Award.

Our programs continue to gain recognition for excellence. We garnered our 34th R&D 100 Award for the Plasma Enhanced Magnetron Sputtering technology. Selected by *R&D Magazine* as one of the 100 most significant developments of the year, PEMS is a new method for depositing super-hard, ultra-thick protective coatings on components. The Aerospace Electronics and Information Technology Division received certification of its quality system to AS9100.

We expanded our internally funded research program, which plays a vitally important role in strategic technical areas and helps develop new ideas that boost innovation and productivity in the physical sciences. We funded 106 projects and increased our internal research expenditures by almost 25 percent to more than $8.7 million. Several promising internal research technologies are discussed elsewhere in this report.

The Institute also continues to invest heavily in new facilities and scientific equipment. A portion of our Space Science and Engineering Division staff moved into a new three-story office and laboratory building, completing a major milestone in our building program.

There is little doubt that we will continue to see challenges in the global economy, and our continued success will require vigilance, discipline and prudent management of costs and resources. Nevertheless, I am pleased to report that our technical programs have remained steadfast. The Institute expanded its technical program output with revenues of $564 million, compared to last year's $563 million. Total payroll to our 3,224 employees was more than $232 million. The number of proposals, and a solid active backlog, are encouraging signs of yet another successful year in 2010.

I hope you find the programs outlined in this report to be interesting and informative. I appreciate the dedication and vision of our staff, trustees and Board of Directors, all of whom are critical to our success. We look forward to providing top-quality technical services and research for our clients in 2010.

Respectfully submitted,

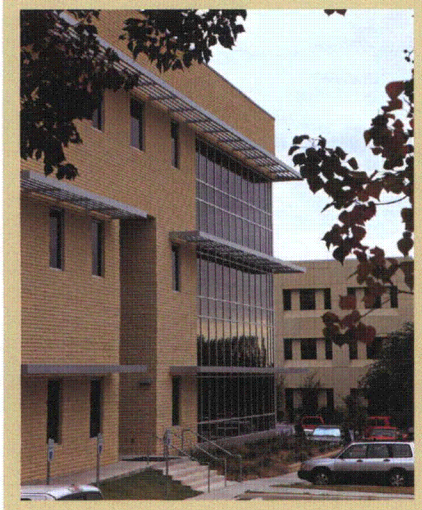
J. Dan Bates, President

Highlights

Southwest Research Institute leads the science investigation for NASA's **Interstellar Boundary Explorer**, which recently completed the first-ever sky maps of interactions occurring at the **edge of the solar system**. The maps revealed a puzzling and unexpected "ribbon" of energetic neutral atom emissions, which researchers theorize is reflecting the alignment of the interstellar magnetic field outside the heliosphere.

Our multidivisional **Mobile Autonomous Robotics Technology Initiative** is developing cooperative vehicle and automation technologies. This year, we implemented and demonstrated cost-effective hardware options and military-style maneuvers, such as vehicle platooning control algorithms.

The U.S. Army renewed its long-term contract with SwRI to continue operating the **Tank Automotive Research, Development and Engineering Center Fuels and Lubricants Research Facility**, which helps the military meet operational and readiness requirements by investigating and solving problems with vehicle fluids.



In 2009, we completed construction on a 32,000-square-foot building to support space science and engineering activities.

Our line of **heavy equipment simulators** for excavation, loading and grading is now commercially available from a large heavy-equipment manufacturer. Using the simulators, new operators can safely and cost-effectively learn about job site hazards, safety violations, machine controls and more.

SwRI continues its long history of organizing **industry cooperative programs** to develop precompetitive technologies that can be incorporated into member company products at relatively low cost. Current programs are developing technologies to **accelerate diesel aftertreatment aging cycles**, to **meet future gasoline engine requirements** and to **reduce diesel engine emissions**.

Our **Plasma Enhanced Magnetron Sputtering** process earned an R&D 100 award, recognizing it as one of the 100 most significant technological achievements of the year. The process can be used to apply erosion- and wear-resistant, super-hard nanocomposite coatings to components operating under harsh conditions, such as jet engine blades and helicopter rotor blades, to protect them from erosion, abrasion and wear.

Staff members continue to support programs to destroy the nation's **chemical agent stockpiles**, including final closure of the Newport, Ind., demilitarization plant. Pine Bluff, Ark., and Umatilla, Ore., chemical agent disposal facilities completed destruction of VX and sarin nerve agents.

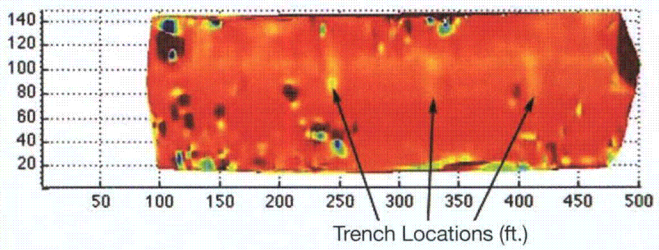
The **SwRI staff** numbered 3,224 employees. Of those, 272 hold doctorates, 518 hold master's degrees and 824 hold bachelor's degrees. The Institute received 31 U.S. patent awards, filed 46 patent applications and submitted 74 invention disclosures. The technical staff published 420 papers and gave 371 presentations.

Internal Research and Development

Our internal research and development program allows staff engineers and scientists the freedom to explore innovative and unproven concepts. Serving as a bridge between new ideas and advanced technologies, the program invests in solutions our clients will need in the future.

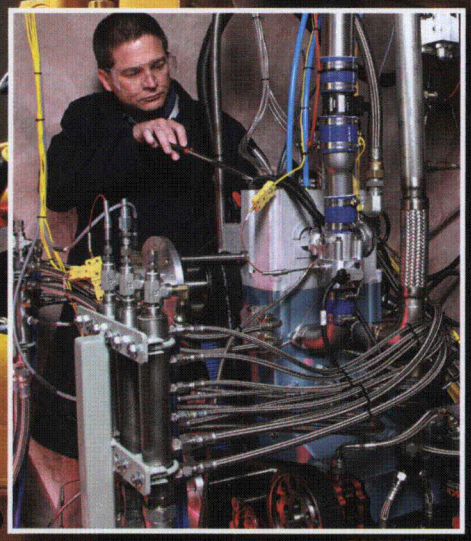
In 2009, SwRI funded $8.7 million to sponsor 106 internal research projects. Some of this year's efforts include:

urea evaporation and mixing system to improve SCR catalyst performance • diesel geartrain NVH performance • expert knowledge capture • active electrochromic thermal control devices • comet modeling • automatic analysis of SIGINT • software-defined radio • ultrasonic signal enhancement and characterization of corrosion damage • nanocomposite coating performance stability • bone mechanobiology • screening technology for tissue regeneration • quantification of carcinogenic pollutants in oils • transient engine performance analysis methods • medium-energy electron spectrometer prototype • lightweight, efficient low-RCS antenna • sampling of multi-channel data • aerodynamic testing of single-stage centrifugal compressor • oxy-combustion burner design • mechanisms for Jovian cloud coloration • design, modeling and fabrication of metamaterials • causes of and preventive measures for destructive abnormal combustion (super-knock) • visually transparent antennas for radio direction finding • geomechanical models of natural rock deformation • interfacing secure digital media with wireless sensors • calibration method for robotic drilling • embedded corrosion sensor technology for reinforced concrete structures • context-based object recognition for mobile platforms • power bus control assembly • DF technology applied to distributed DF antenna array • data transfer and communications for underwater wireless sensor networks



Using internal research funds, SwRI engineers are investigating a magnetometer array concept to detect and display areas of overturned soil that may be obscuring an improvised explosive device. The figure shows one such experiment where trenches were identified by the prototype system.

Automotive Engineering



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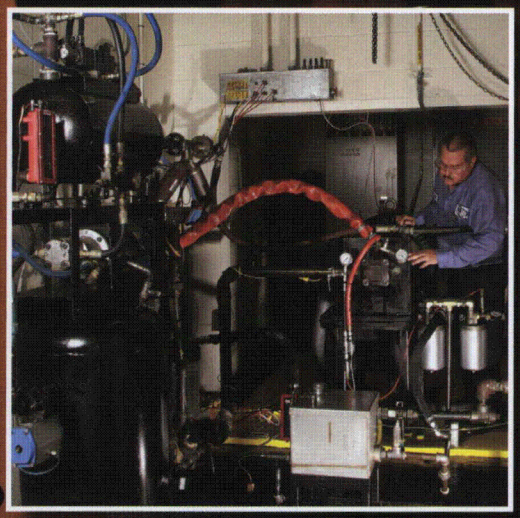
SwRI engineers have developed a unique hardware-in-the-loop test facility to decrease development costs and the time to market new component designs. The HIL facility shown will develop and evaluate advanced conventional and hybrid powertrains.



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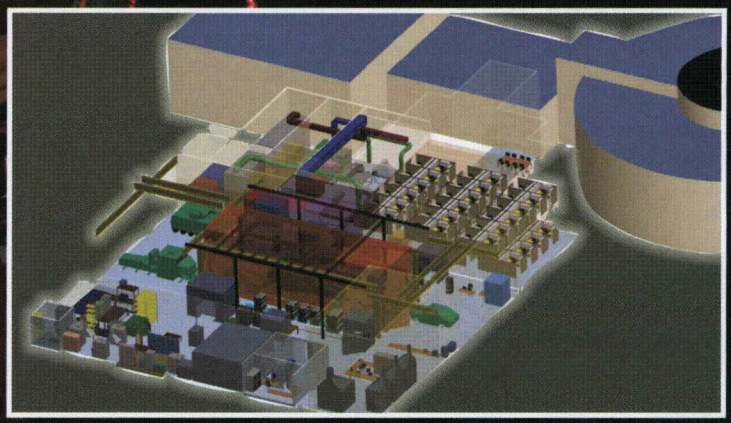

3

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gasoline & diesel engine lubricant evaluations • driveline fluids evaluations • filtration evaluations fuels performance & qualifications • analytical support services • fuel economy evaluations 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 alternative fuel evaluations • powertrain modeling & controls development • engine development

With more than 60 years of experience in engine and vehicle component design and development, engine and emissions research, and fuel and lubricant evaluations, Southwest Research Institute pulls together staff members from a wide variety of disciplines to tackle our clients' on- and off-road vehicle projects from every direction. Our development and evaluation capabilities are internationally recognized and meet the highest quality standards.

Our automotive design services range from complete engine design to detailed component analysis (engine design.swri.org). For one commercial client, we designed and analyzed a unique two-cylinder, split-cycle prototype engine. Unlike the typical four-stroke process used by standard gasoline and diesel engines, this engine splits the two sets of strokes into two separate cylinders; the intake and compression strokes take place in one cylinder and the expansion and exhaust strokes take place in the other. This design optimizes the compression and combustion processes, believed to provide significant exhaust emissions advantages, and potentially enables a cost-effective air-hybrid engine design.

We designed a new cylinder head to help heavy-duty diesel engines meet forthcoming international emissions standards. Engine and vehicle original equipment manufacturers from around the world have shown interest in the design's potential to achieve 250-bar peak cylinder pressure.

Our Ann Arbor, Mich., staff continues supporting the Environmental Protection Agency's Clean Automotive Technology program, which involves the development of custom hydraulic hybrid control modules to maximize fuel economy on delivery vehicles (annarbor.swri.org).

As part of the Advanced Collaborative Emissions Study organized by the Department of Energy with the Coordinating Research Council and the Health Effects Institute, our engineers examined emissions from four 2007 model year, heavy-duty highway diesel engines, characterizing regulated emissions, ultrafine and nano-particles, and more than 795 unregulated species in the gas and particle phase. The study confirmed the engines successfully achieved lower emission levels than those mandated by the 2007 standard while reducing the great majority of unregulated pollutants, compared to pre-2007 technology engines (emissionsresearch.swri.org).

As the focus on renewable fuels sharpens, legislation is requiring suppliers to confirm that new fuel formulations do not increase vehicle emissions or cause engine and vehicle durability issues. For EPA, DOE, the National Renewable Energy Laboratory and the Coordinating Research Council, our researchers are examining the fuels' effects on light-duty vehicle emissions. For DOE and the Oak Ridge National Laboratory, we also are assessing the effects of ethanol blends on catalytic converters and long-term vehicle emissions.

To help advance pre-competitive technologies, SwRI organizes cooperative research programs that allow members to pool funds to develop new technologies at significantly lower cost. SwRI initiated the Diesel Aftertreatment Accelerated Aging Cycles — Heavy Duty consortium to develop application dependent, accelerated aging procedures for diesel aftertreatment components, which could save both time and expense to achieve certification requirements (daaac.swri.org). Current members include engine manufacturers from the United States, Japan, Europe and Korea, as well as lubricant and catalyst companies.

Our High-Efficiency Dilute Gasoline Engine consortium continues to develop the enabling technologies required for gasoline engines to meet the performance, durability and emissions requirements of future motor vehicles while improving efficiency. HEDGE™ has 17 members representing engine manufacturers, component suppliers, and oil and gas providers (hedge.swri.org).

In 2009, the U.S. Army renewed its long-term contract with SwRI to operate the Tank Automotive Research, Development and Engineering Center Fuels and Lubricants Research Facility

1. *For a commercial client, SwRI engineers are developing a split-cycle engine that directs intake and compression strokes into one cylinder and expansion and exhaust strokes in another. Preliminary analysis suggests the design can help reduce emissions (engine design.swri.org).*

2. *Our engineers designed and built a hydraulic fluid energy efficiency test stand that precisely measures energy efficiency gains of reformulated hydraulic fluids.*

3. *SwRI designed a new U.S. Army TARDEC Ground Systems Power and Energy Laboratory to evaluate the environment, power, electrical power architecture systems, electric components, pulse power and directed energy, thermal fluids, fuel cells and air flow filtration of an array of military vehicles (tardec.swri.org). GSPEL will be built alongside TARDEC's existing test facility, shown in blue, at the Detroit Arsenal in Warren, Mich.*

4

D1M017035-7578

The R-FOCAS® burner-based exhaust catalyst aging system offers many advantages over engine-based aging methods, such as elevated aging exhaust temperatures and reduced maintenance (focas.swri.org). In addition, lubrication oil can be injected into the exhaust stream to add oil poisoning effects to any catalyst aging cycle.

5

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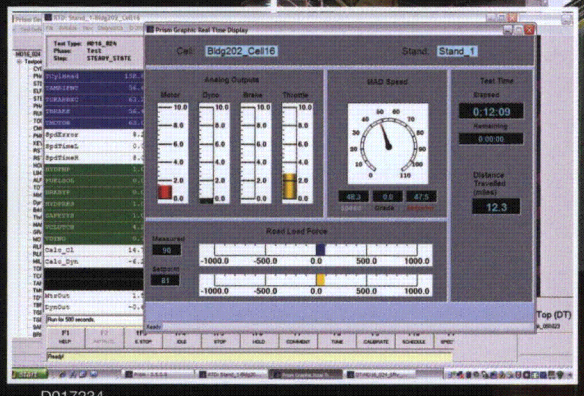

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high-efficiency gasoline engine research • generator set & combined heat & power evaluations homogenous charge compression ignition • hydraulic design • hardware-in-the-loop evaluations light-duty fuel economy & production calibration • marine & recreational products & research hybrid vehicle design • vehicle testing • contamination research • wear evaluations accelerated durability evaluations

(tardec.swri.org). The laboratory helps the military meet operational and readiness requirements by investigating and solving problems with vehicle fluids. Army-funded laboratory renovations are ongoing and will allow for the continuation of the Army's fuels and lubricants research mission, which includes the adoption and use of sustainable energy resources and alternative fuels in the present and future Army fleet.

SwRI designed a new Ground Systems Power and Energy Laboratory to be built alongside TARDEC's existing facility in Warren, Mich. The Army will use the facility, which broke ground in August, to examine existing military vehicles and to assess the viability of developing hybrid-electric and fuel-cell military vehicles.

SwRI has performed comprehensive fuel economy evaluations on fluids and automotive devices for the trucking industry for more than 20 years (fueleconomytesting.swri.org). In accordance with industry standards, we evaluate fuel consumption during operating cycles representative of bus, pick-up and delivery, and refuse operations, as well as long-haul truck fleets. Staff members use a dedicated scale accurate to 0.1 pound and consistent driving patterns to maintain accuracy. Vehicle operating conditions such as truck and engine speed, coolant temperature and turbo boost pressure also can be monitored and recorded.

Increasingly stringent fuel economy regulations are creating higher demands for vehicle, component and fluid evaluations. In addition to offering a multitude of evaluation services, SwRI has taken a lead role in developing new test methods and systems (enginelubes.swri.org).

We recently designed and built a new test stand that precisely measures energy efficiency gains associated with improved hydraulic fluids for oil and additive manufacturers. Mobile and plant equipment use massive amounts of energy to power hydraulics so small gains in efficiency can create significant economic gains.

ASTM International recently accepted the ROBO test procedure co-developed at SwRI for inclusion in the next engine oil category, GF-5. The test evaluates used oil low-temperature performance in the Sequence IIIGA test, one of a series of specifications engine oils must meet before entering the global marketplace. The GF-5 specification targets emission system compatibility and engine cleanliness, as well as fuel economy and fuel economy retention.

ASTM also accepted the SwRI co-developed Sequence VID fuel economy test, which will be used by the lubricants industry over the next several years in every engine lubricant fuel economy evaluation we conduct.

We have been a major participant in working to finalize development for the American Petroleum Institute's next gasoline engine lubricant specification, designated SN. SwRI's contributions to the Sequence VID economy test and the ROBO analytical bench test were key to the development of this specification.

Our engineers helped develop the new catalyst-compatible FC-W specification, approved by the National Marine Manufacturers Association, designed to limit catalyst poisoning in four-stroke marine engines.

Our internal research program helps fund the advancement of new automotive test methods and systems. Using this funding, we are developing a standard method to identify and quantify eight polycyclic aromatic hydrocarbons, which are used in tire manufacturing in Europe. The new method will measure these hydrocarbons in low concentrations with high precision and accuracy, assuring the quality of the oil before it is used in the manufacture of tires. ❖

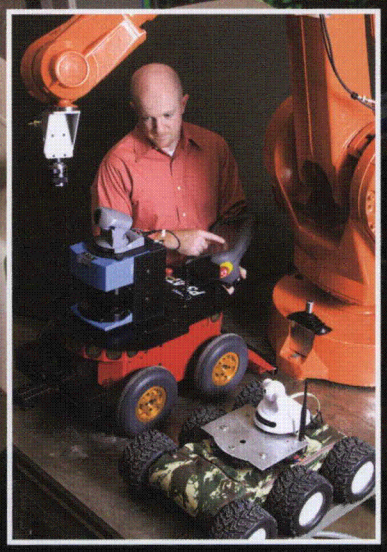
Visit fuelsandlubricants.swri.org or engineandvehicle.swri.org for more information or contact Vice President Lee Grant at (210) 522-5004 or lee.grant@swri.org or Vice President Bruce Bykowski at (210) 522-2937 or bruce.bykowski@swri.org.

4. *The South Texas climate provides ideal weather for conducting on-road fuel economy evaluations for the trucking industry year-round. Our engineers evaluate the vehicles on public highways and roads, at grades up to 11 percent. We also maintain a paved test track with 0.6-mile straightaways at our 1,200-acre headquarters in San Antonio.*

5. *A new test cell developed at SwRI evaluates vehicle radiators, coolants, and related components and fluids from vehicles ranging in size from compact cars to Class 8 trucks and military vehicles under a variety of conditions. As an independent research and development organization, SwRI provides third-party verification testing of these systems.*

6. *We successfully integrated our Prism® data acquisition software into SwRI mileage accumulation dynamometers. The first stand is now in service with Prism controlling the critical road load force parameters more closely than the software program it replaces.*

Automation and Data Systems



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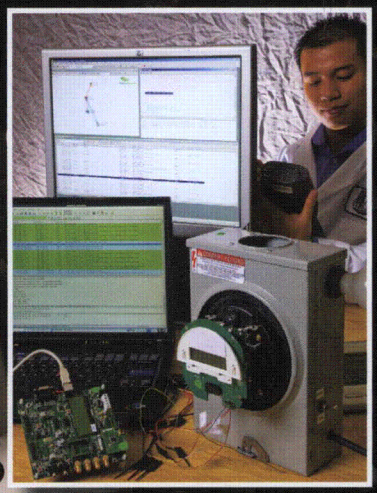

2

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3

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In collaboration with local universities, SwRI is developing a bioreactor system that provides continuous nutrition to mesenchymal stem cells as well as precise control of the temperature, oxygen, carbon dioxide tensions and perfusion flow to mimic the bone marrow environment. The bioreactor provides an important tool to study cell-to-cell and cell-to-matrix interactions, mesenchymal stem cell migration, and growth factors and cytokines that regulate MSC self-renewal and multi-lineal differentiations within the bone marrow environment.

4

D17232

D017144-1236

enterprise software • cyber & application security • automated inspection • smart grid • process re-engineering embedded systems & security • image & signal processing • radar & remote sensing • machine vision autonomous vehicle technologies • orthopedics • reconfigurable communications • biomedical research network modeling & simulation • robotics • SEI CMMI® Level 5 software design • network-centric systems intelligent transportation systems • cooperative vehicle technologies • green efficient manufacturing control center software • aerospace networks • MEMS & microfluidics • data management & mining lean manufacturing • medical device development • tactical networks

Southwest Research Institute is developing and applying the latest digital, communications and automation technologies in such diverse areas as green energy and manufacturing applications, intelligent transportation, human health, and information and network security.

In addition to ongoing research in application, network and system security, we are helping to secure our nation's critical infrastructure. For example, although smart grid applications hold promise for saving energy, reducing costs and increasing reliability of electric power, this emerging technology must overcome several challenges. SwRI developed techniques to conduct security penetration testing for multiple utilities to identify and mitigate system vulnerabilities. This testing requires an interdisciplinary set of security knowledge and skills including wireless networking, serial interfaces, encryption, bus sniffing, software reverse engineering and physical device security — capabilities that we also apply to other embedded devices such as vehicle controllers, communications devices and weapon systems (systemsecurity.swri.org).

Through our Texas Manufacturing Assistance Center, we helped more than 60 small- and medium-sized companies become more globally competitive and employ more green efficient manufacturing technologies in 2009. We launched a first-of-its-kind Lean, Clean Energy program where, in cooperation with CPS Energy, we provided assessments and training allowing local manufacturers to measurably improve energy efficiency and reduce waste. Manufacturers implementing our recommendations fully recover their costs through rebates, incentives and utility cost savings. TMAC also began a focused program to help aerospace suppliers implement lean practices and meet AS9100 quality systems (tmac.swri.org and manufacturing.swri.org).

Our machine vision experts developed a video-based system that uses digital signal processing algorithms to automatically detect human behavior, specifically identifying bed-exiting in a nursing home environment to help prevent falls. SwRI is enhancing the bed exit detection system, which is part of a long-term care management system, with additional algorithms to detect bed entry, room entry, wheelchair exiting and other behaviors (machinevision.swri.org).

Our engineers continue to create and implement intelligent transportation system applications, such as a variable tolling system for Florida's express lanes and a statewide data infrastructure to support the 511 traveler information system deployment. In Texas, we consolidated various systems and software components to form a new product called the Lonestar™ system (its.swri.org). With the next phase of ITS focusing on vehicle autonomy and cooperative vehicle technologies, SwRI is using internal funds to investigate how autonomous vehicle algorithms perform in urban environments that are difficult for piloted vehicles to maneuver effectively. We are also prototyping the use of dedicated short-range communications for vehicle-to-vehicle and vehicle-to-roadside communications (ivs.swri.org).

Collaborating with the University of Texas Health Science Center in San Antonio, the University of Texas at San Antonio and SwRI chemists, our bioengineers developed a mesenchymal stem cell bioreactor. This system uses a three-dimensional scaffold with a bone-like porous architecture to mimic the bone marrow environment and supplies continuous nutrition and environmental control. The *in vitro* system could potentially provide a continuous source of blood cells for transfusion as well as MSCs for tissue regeneration and wound healing applications (bioengineering.swri.org). ❖

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

1. *Through an internal research project, SwRI engineers developed a software-based robot abstraction library, enabling many different types of robots to be controlled from a standard interface. This technology eliminates the need for platform-specific operator training and encourages reuse of high-level software control modules, reducing the cost of developing and deploying new robotic applications.*

2. *In support of smart grid applications, we are performing embedded systems and network security penetration testing for multiple utilities to identify and mitigate system vulnerabilities. In addition, we are addressing other smart grid planning, design and development issues, such as modeling and simulation, as well as communications infrastructure and enterprise system data management and analysis.*

3. *Our engineers apply network technologies to improve scalability and flexibility of systems in a wide variety of industrial and government domains. Recent systems include a network-centric data acquisition and recording system for flight testing of commercial airplanes and a network-based communication data bus architecture that integrates various military communication and electronic warfare equipment on tactical and combat vehicles.*

4. *The multidivisional Mobile Autonomous Robotics Technology Initiative continues developing cooperative vehicle and automation technologies. In 2009, we implemented and demonstrated new, cost-effective hardware options and military-style maneuvers to our MARTI™ autonomous vehicle platform, including vehicle platooning control algorithms that allow fleets of vehicles to share information and travel more efficiently and cooperatively.*

Training, Simulation and Performance Improvement

Our line of heavy equipment simulators for excavation (shown), loading and grading is now commercially available from a large heavy equipment manufacturer. Using the simulators, new operators can safely and cost-effectively learn about job site hazards, safety violations, machine controls and more.

1

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3

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operations & maintenance training simulators • performance support • web-based simulation instructional systems • physics-based modeling • blended learning • behavior modeling • web 2.0 certification programs • structured on-the-job training • distributed simulation • enterprise systems virtual reality/environments • visual analytics • SCORM • expert knowledge transformation • e-testing Section 508 • learning content management systems

As a leader in meeting clients' workplace challenges, Southwest Research Institute offers one of the widest selections of training and simulation techniques and delivery modes available.

We are embracing blended learning, which combines virtual and physical learning approaches, using multiple delivery methods such as smart phones and social networking tools. Our automated, web-based Assisted Blended Learning Environment decision support tool allows training personnel to determine the best blend of instruction for maximum retention. The tool considers classroom, web-based, simulation, on-the-job, mobile, social and other learning methods.

SwRI continued development of our line of commercially available heavy equipment simulators. The first system, available in 2008, cost-effectively trains operators on excavators. In 2009, we completed four-wheel drive loader and motor grader simulators. Each system includes desktop software and controls that replicate equipment in the vehicle cab. The simulators teach operator techniques, safety procedures and machine controls in a virtual, risk-free environment.

The Generalized Operations Simulation Environment tool allows SwRI analysts to cost-effectively build and deliver immersive learning products and serves as the backbone of several simulation programs (simulation.swri.org). Using this software, we have built virtual F-15 and A-10C aircraft simulators and several web-based telecommunications courses. This year, we expanded GOSE™ to include a tool that enables clients to build courses. Non-programmers can use an interactive interface to rapidly develop immersive, simulation-based training.

We also have developed a tool suite to help instructional developers reduce course creation time while conforming to shareable content object reference model standards and specifications. The suite includes a content development and delivery engine, a library of more than 40 dynamic content templates, tools to auto-generate pre- and post-tests, and a course generator tool that creates a SCORM-conformant course package.

As clients increasingly require unique delivery methods for information and training, we developed a prototype "wearable workspace" to give technicians hands-free access to electronic reference manuals in industrial settings. The system uses a lightweight, head-mounted display, a wearable computer and components to capture head gestures, enabling the technician to efficiently interact with data. Voice recognition, or a combination of both methods, also can be used to control the system.

Our team continues to support the Air Mobility Command at Scott Air Force Base, Ill., developing new features and enhancements for the Aircraft Maintenance Training Enterprise System (instructional.swri.org). Recent changes to the e-testing capability allow Air Force Reserve and Air National Guard units to access the system from non-military networks via the Air Force Portal.

Since 2003, SwRI has helped organizations capture expert knowledge at risk of being lost through staff retirements and attrition. Our five-step expert knowledge transformation model helps organizations identify and prioritize the knowledge at risk, capture knowledge using a range of extraction techniques and code it for reuse throughout the organization. SwRI's Expert Knowledge Manager tool suite supports the EKT process. The EKM includes a capture prioritization tool, knowledge extraction and question guides, and a digital player that allows the expert knowledge to be viewed on a variety of devices to include mobile delivery options.

The staff developed a process to validate course compliance with Section 508 of the Rehabilitation Act, which requires that people with disabilities can access and use government information and data. With this process, courses can be re-engineered at significantly lower costs to meet government standards for the disabled. ❖

Visit tsystems.swri.org for more information or contact Vice President Dr. Katharine Golas at (210) 522-2094 or katharine.golas@swri.org.

1. *SwRI engineers developed a "wearable workspace" that allows technicians to reference technical manuals using voice recognition or a head-mounted tracker, which is useful in noisy industrial settings.*

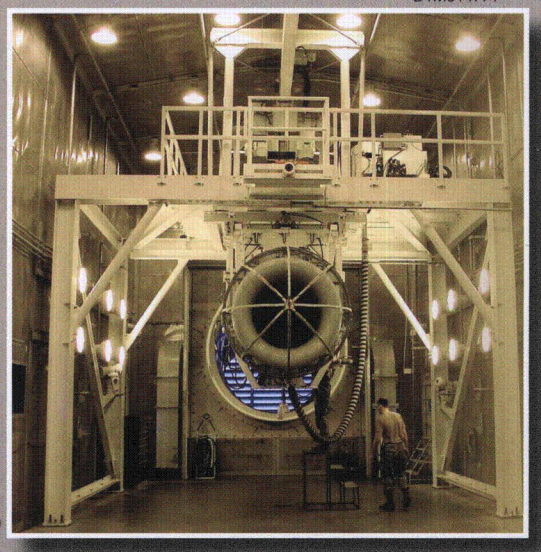
2. *One of our web-based and immersive simulation training systems trained more than 70,000 telecommunications students this year, resulting in a 2009 Supplier Award from a major client.*

3. *Our web-based Assisted Blended Learning Environment decision support tool helps training personnel make a comprehensive assessment of instructional methods available and "blends" the best methods for maximum learning and retention.*

Aerospace Electronics and Information Technology

D1M014771

SwRI engineers recently began a multi-year effort to design a new chaff-flare dispenser system used by the A-10 aircraft fleet during close-air support missions.



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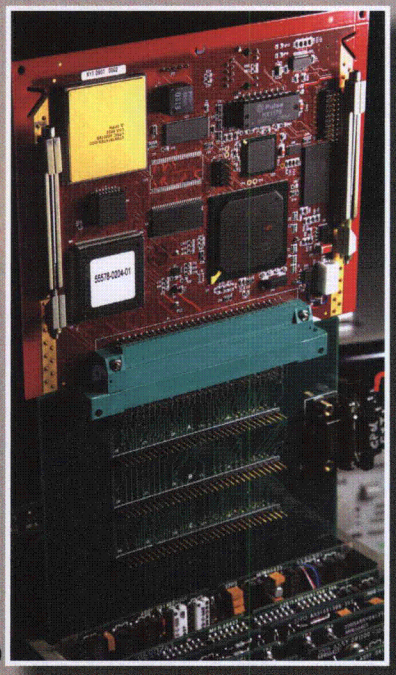

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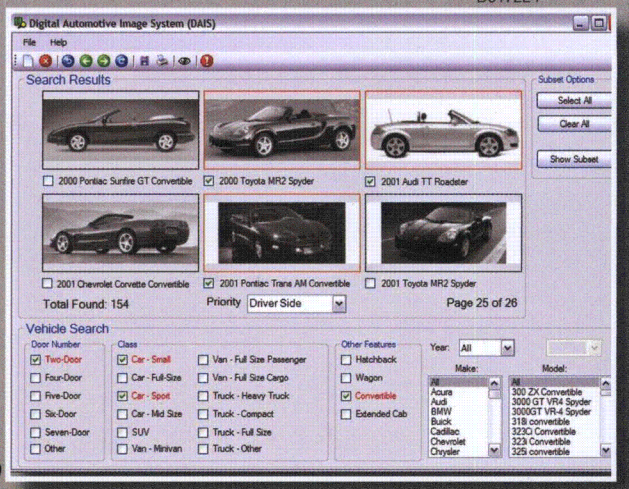

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Courtesy Senior ... Stephen Otero, U.S. Air Force, D017218

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

Southwest Research Institute provides products and engineering services to the domestic and foreign aerospace industry, offering particular expertise in aerospace propulsion and electronic systems and components.

Staff members are continuing to assist the U.S. Air Force with design modifications and upgrades to 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 2028 (aircraftsystems.swri.org).

We led upgrades to the A-10 head-up display unit to improve reliability and maintainability. Four units are being field tested at Nellis Air Force Base, Nev. We also are supporting aircraft maintenance and diagnostic processes, including ground-based automatic test equipment and on-board test systems.

SwRI operates engineering support offices for Air Logistics Centers in Oklahoma City; Warner Robins, Ga.; and Layton and Ogden, Utah. Our Oklahoma staff is assisting the Air Force and Army with all aspects of turbine engine test cell design, installation, calibration, documentation and correlation. We are developing new technologies to reduce maintenance and downtime as well as new systems to recover and convert large amounts of energy previously wasted to electrical power.

SwRI invests in promising technologies through internal research programs designed to jump-start client-funded research. To reduce maintenance costs and improve reliability of aircraft engines, SwRI has developed multivariate statistical analysis techniques that provide significantly earlier detection and diagnosis of excessive wear and failure events in turbine engines. This technology can be applied to other machinery in various industries.

At Warner Robins, SwRI performs updates to electronic warfare systems, modifying software, upgrading automated test systems and validating system changes. SwRI is the primary support contractor for the Electronic Attack Pod program, a critical system that protects Air Force aircraft from ground and air missile attacks. We verify and validate attack pod software products to ensure the operational fidelity of system updates. Using high-fidelity simulation and emulation systems, our engineers "fly" the pod in a simulated environment to measure its effectiveness against enemy threats, significantly reducing flight test costs and updating turnaround times.

SwRI developed and now hosts and maintains the Air Force's Joint Reliability Availability Management System. This integrated information management system provides an extensive suite of analysis tools to support aircraft maintenance, supply, operations and availability management. J-RAMS helps equipment, system and aircraft managers effectively apply limited resources to broad mission responsibilities.

Our Utah staff continues its support of reliability and maintainability issues for avionics and related equipment at Hill Air Force Base.

To help users improve engineering and business practices, SwRI develops user-friendly software systems and tools that lower costs and improve efficiency by streamlining, automating and standardizing processes. For example, we applied this expertise to a vehicle database that law enforcement officials can use to identify vehicles involved in crimes.

Building on an ISO 9001:2000 international quality certification, our aerospace electronics and information technology efforts were certified to the AS9100 Quality Management System for the aerospace industry, which includes additional quality and safety requirements. ❖

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

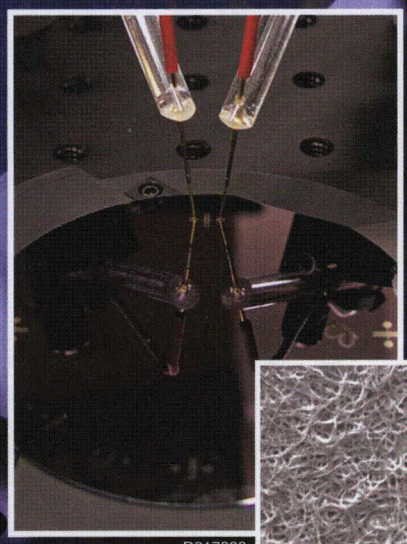
1. *Our engineers developed a compact, low-power avionics board for real-time turbine engine monitoring. The Razorback-300 modernizes legacy aircraft systems while remaining compatible with previous generation support equipment (rb300.swri.org).*

2. *We develop and maintain instrumentation for the thrust frames and adapter kits used to test B-2 and C-5 jet engines for the Air Force.*

3. *Our staff completed development of the Digital Automotive Image System, an investigative tool containing detailed vehicle images and technical specifications. Law enforcement personnel will use the system to gather vehicle data and to create "Be On the LookOut (BOLO) For" posters.*

Mechanical Engineering

SwRI engineers designed and built a novel wind turbine array system and evaluated a prototype in a large wind tunnel. We also conducted computational fluid dynamic simulations, validated by experimental data, to better understand the structure of the flow through the turbine array.



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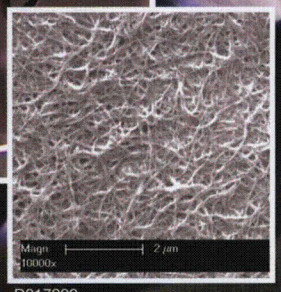

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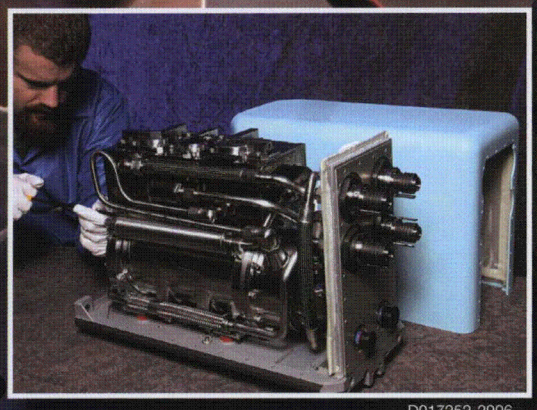

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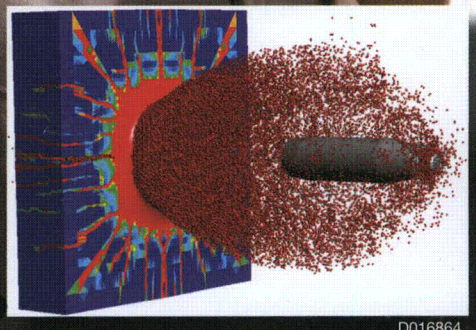

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computational fluid dynamics • deep ocean simulations • fracture mechanics • flow measurement acoustics • probabilistic failure analysis • environmental testing • surface engineering & coatings telecommunications evaluations • structural mechanics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

Energy, aerospace and defense remain core areas of business at Southwest Research Institute, particularly in oil and gas production and transmission, renewable energy, military and commercial aircraft, manned submersibles, space hardware and military ground vehicle armaments. We are applying our expertise in sensors, fluids, materials, structures and mechanical engineering to help clients improve the safety, reliability, efficiency and life of their systems.

In the energy arena, we are continuing compressor system design analysis for the natural gas pipeline industry initiated in the early 1950s. Recent technological breakthroughs at SwRI have resulted in more advanced compressor pulsation control methods, resulting in smoother running, more efficient and more reliable compressors (pulsations.swri.org).

As offshore oil and gas production continues expanding into deeper waters, we continue to expand and improve our capabilities to address extreme temperatures and high pressures associated with these challenging environments. We have added sophisticated new experimental facilities to address corrosion fatigue, multiphase flow assurance and product assurance needs in deep-water environments.

We also develop nondestructive sensor and data analysis techniques to inspect piping, nuclear reactors and other infrastructure for defects that could cause system failures (ndetech.swri.org).

In addition to conventional energy production, we support the emerging wind turbine industry, helping improve the reliability and extend the operating life of gearboxes in large land-based installations (windpower.swri.org). The ability to store energy and match production with demand is key to broader deployment of renewable energy technologies, such as wind turbines and photo-voltaic solar cells. SwRI is developing computational methodologies to support designing materials to advance the power, efficiency and durability of batteries used in hybrid, plug-in hybrid and electric vehicles, as well as stationary power storage.

In the defense arena, we are evaluating SwRI- and client-developed armor concepts using ballistics testing and numerical simulations to help protect personnel from the devastating effects of improvised explosive devices. We also use probabilistic modeling and simulation techniques to evaluate various vehicle and occupant safety enhancements associated with collision, blast, fragment impact and rollover scenarios (compmech.swri.org).

In the aerospace field, we continue working with the Air Force to help maintain the structural health and extend the service life of the T-38 advanced supersonic jet trainer and the A-10 weapons system (structuralintegrity.swri.org). We are helping the Army implement condition-based maintenance for its CH-47 helicopters, and we evaluated the static strength of an aircraft wing structure (verylightjet.swri.org).

In 2009, we transitioned from design to fabrication of the next-generation deep ocean research submersible, successfully forming and joining the titanium hemispheres of the crew enclosure. The new submersible design will withstand depths of 6,500 meters, allowing access to 99 percent of the ocean floor.

The Institute recently built a new crash test facility to perform full-scale vehicle crash testing on our grounds. The 600-foot-long, 100-foot-wide crash pad provides a large, secluded, secure and unobstructed area for highway safety system and other large-scale evaluations.

We developed a plasma enhanced magnetron sputtering process for applying erosion- and wear-resistant, super-hard nanocomposite coatings to components such as turbine blades and petroleum exploration equipment. In 2009, *R&D Magazine* selected the PEMS process as one of the 100 most significant technological advancements of the year (surfaceengineering.swri.org). ❖

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

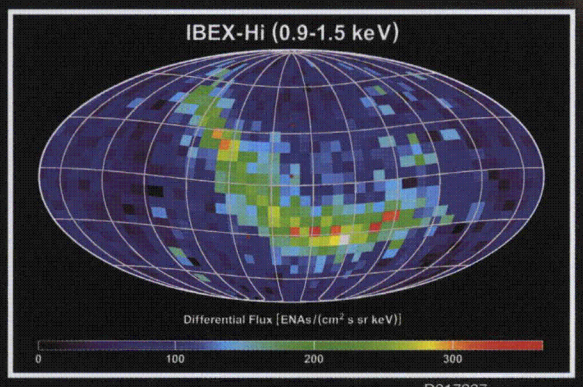
1. *In 2009, our scientists developed carbon nanotube-based sensors capable of providing reliable, real-time detection of chemical and biological agents as well as physical changes in their surroundings. The sensors utilize high surface area designer biomolecules (inset) and/or chemoselective polymers and are promising candidates for real-world applications ranging from chemical warfare agent detection to* in vitro *medical diagnostics.*

2. *SwRI engineers designed and fabricated the compressor for the International Space Station's Sabatier system, which uses waste streams of carbon dioxide and hydrogen to manufacture water on-orbit.*

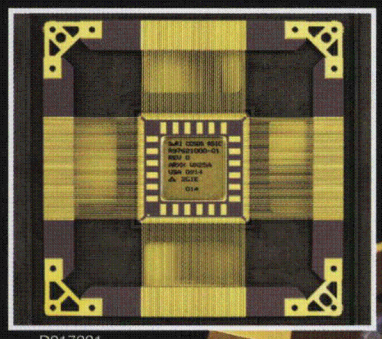
3. *Our nondestructive evaluation specialists are developing inspection technologies to detect defects in buried cast iron pipes.*

4. *Our computational specialists continue improving the Elastic-Plastic Impact Computations code used to simulate high-powered ballistic events. Recent advances allow EPIC to generate and characterize behind-armor debris fields produced in the wake of perforated targets, such as this debris field produced when a tungsten projectile perforated a steel target.*

Space Science and Engineering



1 *Courtesy NASA/IBEX* D017237



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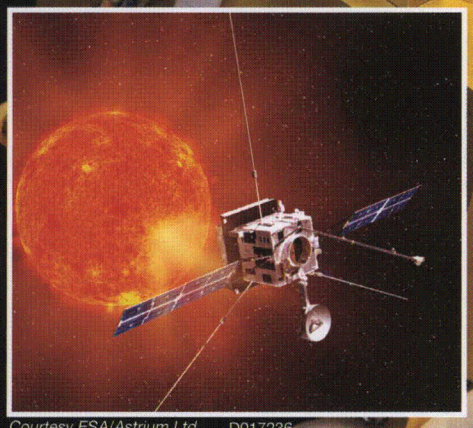
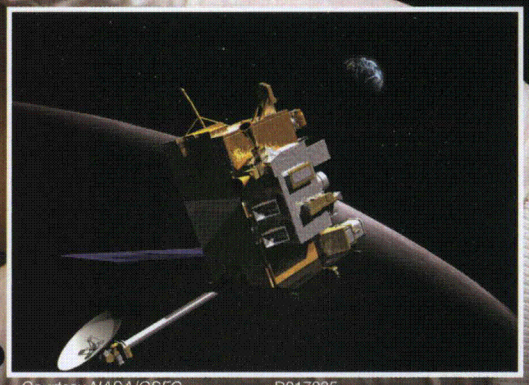
SwRI developed the Radiation Assessment Detector for the Mars Science Laboratory, scheduled for launch in 2011. RAD will measure fluxes of solar energetic particles and cosmic rays at Mars' surface, providing data needed to characterize the Martian radiation environment in preparation for possible future human exploration.



3 *Courtesy ESA/Astrium Ltd.* D017236



4 *Courtesy NASA/GSFC* D017235

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electromechanical systems design • spacecraft management • spacecraft avionics systems design spacecraft instrument systems • 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

Southwest Research Institute remains a recognized leader in space science as well as in the development of spacecraft *in-situ* and remote-sensing instrumentation, avionics, and electronics for both government and industry.

SwRI leads NASA's Interstellar Boundary Explorer mission, which recently completed the first-ever sky maps of energetic neutral atom emissions from the edge of the solar system. Compiled over a six-month period of data collection, the IBEX maps reveal a bright, narrow band of ENA emissions unpredicted by existing theories or models of this turbulent region, where the million-mile-an-hour stream of plasma flowing from the Sun encounters the local interstellar medium. IBEX is gathering data for a second sky map, which will document any temporal changes in this mysterious feature.

Following the successful launch of NASA's Lunar Reconnaissance Orbiter in July, the SwRI-built Lyman-Alpha Mapping Project has been mapping the ultraviolet reflectivity of the Moon, concentrating on the permanently shaded regions near the north and south poles. LAMP also observed the impact of the Lunar Crater Observation and Sensing Satellite (LCROSS) in the crater "Cabeus" near the Moon's south pole and obtained excellent spectra of the ejecta plume. SwRI scientists also studied the impact with ground-based telescopes in New Mexico and Hawaii.

LAMP is one of several SwRI-developed imaging spectrometers operating in space. Nearly identical instruments are flying on NASA's New Horizons mission to Pluto and the European Space Agency's Rosetta comet mission. We are building the ultraviolet spectrometer for NASA's New Frontiers Juno mission to Jupiter, for which we are also providing the Jovian Auroral Distributions Experiment, a pair of sensors that will measure the electrons and ions that produce Jupiter's powerful aurora. Scheduled for launch in 2011, Juno will be the first spacecraft to study Jupiter from a polar orbit and is expected to yield important new insights into Jupiter's composition, internal structure and giant magnetosphere.

SwRI heads the science investigation for NASA's four-spacecraft Magnetospheric Multiscale mission, which will use Earth's magnetosphere as a "laboratory" to study magnetic reconnection, a universal astrophysical process that converts magnetic energy into kinetic energy and heat. In addition to overseeing the MMS science investigation, our staff is developing the hot plasma composition analyzers as well as the central data processing units for the payload. MMS passed its confirmation review and is now in the implementation phase. Launch is planned for 2014.

Staff members are building instruments for two European Space Agency missions. The Spectral Imaging of the Coronal Environment (SPICE) spectrograph is designed to fly on Solar Orbiter, a mission to investigate the origins of the solar wind and its evolution in the inner solar system. The BepiColombo Mercury orbiter will fly a suite of particle instruments, including our "Strofio" instrument, which will measure the neutral particles ejected from Mercury's surface to form the planetary exosphere.

The Institute has provided avionics for more than 50 missions without a single on-orbit failure. SwRI avionics systems are currently flying on the Worldview-2 imaging and mapping satellite, as well as NASA's Kepler and Fermi Gamma-Ray Space Telescope missions. The Wide-field Infrared Survey Explorer, launching in December, will survey the entire sky, detecting infrared emissions from a variety of astronomical objects, ranging from cosmic dust to brown dwarfs and ultra-luminous galaxies.

Staff members also are continuing development of the HiSentinel stratospheric airship and developing concepts for planetary exploration missions utilizing balloon platforms. ❖

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

1. *This IBEX sky map shows the bright ribbon of energetic neutral atom emissions emanating from the upstream region where the solar wind encounters the local interstellar medium. SwRI scientists, in cooperation with other members of the IBEX science team, are studying this puzzling and unexpected feature. Researchers theorize that the ribbon reflects the alignment of the interstellar magnetic field outside the heliosphere.*

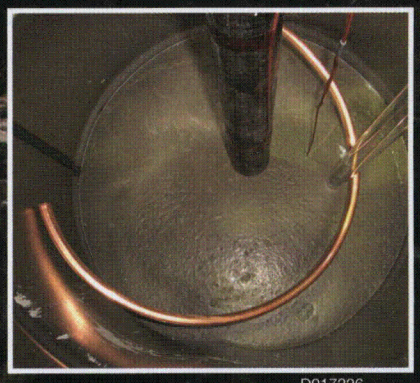
2. *SwRI avionics engineers have developed innovative Application-Specific Integrated Circuits compatible with Consultative Committee for Space Data Systems standards. These ASICs are an enabling technology for future low-power, low-mass and low-volume spacecraft avionics systems.*

3. *The Spectral Imaging of the Coronal Environment ultraviolet spectrograph project led by SwRI was selected by NASA for the European Solar Orbiter mission, which will employ a combination of remote-sensing and* in-situ *instrumentation to investigate the origins of the solar wind and its evolution in the inner solar system.*

4. *This artist's concept illustration shows the Lunar Reconnaissance Orbiter spacecraft in orbit some 30 miles above the surface of the Moon. Institute researchers are analyzing data from the SwRI-built LAMP instrument for evidence of water ice in the permanently shadowed craters in the Moon's northern and southern polar regions.*

Geosciences and Engineering

This year, we developed two new structural geology training courses for the oil industry, using the natural laboratory provided by exposed geologic features at the Canyon Lake Spillway, just north of San Antonio.



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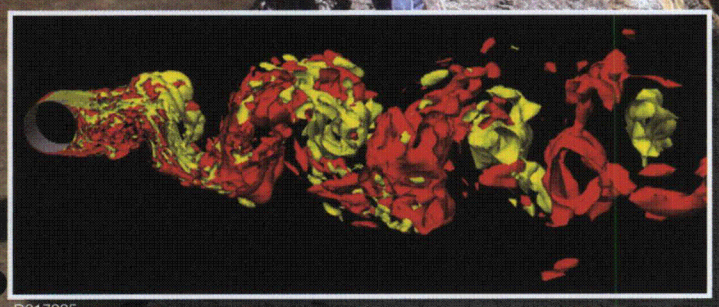

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Courtesy U.S. Army Corps of Engineers

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geophysical & geological investigations • groundwater resource evaluations • geological structure analysis 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

For more than two decades, Southwest Research Institute has been building a center of excellence in geosciences and engineering, initially applying this expertise to long-term radioactive waste storage and disposal before transferring this expertise to oil and gas, water resource and planetary research programs. Fluctuating energy costs and policies are affecting the directions of some of our core energy-based activities, particularly in nuclear energy and waste management; however, we continue to be a technical resource for the Nuclear Regulatory Commission as well as other government agencies and commercial endeavors, here and abroad.

We continue operating the Center for Nuclear Waste Regulatory Analyses, providing technical support associated with considerations relating to the possible licensing of a potential geologic repository for high-level radioactive waste (cnwraweb.swri.org). In this connection, the year's activities focused on assisting the NRC with its review of the Department of Energy's license application and associated environmental impact statement. In support of these activities, CNWRA developed secure shared information management systems to provide configuration control and joint workspace for thousands of pages of electronic documentation. CNWRA technical expertise is available to support possible changes in the U.S. waste management program, other parts of the nuclear fuel cycle and nuclear energy programs worldwide.

For example, we developed a computer model to analyze the performance of nuclear waste disposal systems in Japan, and we continue developing and applying the MARFA tool to model and analyze radionuclide transport for a geological repository for spent nuclear fuel in Sweden.

We continue to participate in advancing the understanding of long-term risks associated with storing and disposing radioactive waste, ranging from evaluating general and localized corrosion of nuclear waste packages to conducting probabilistic assessments of facility vulnerabilities from natural phenomena such as earthquakes, volcano eruptions and tsunamis, as well as impacts from aircraft crashes and other accidents.

Our services to the worldwide oil and gas industry continue to expand, particularly in structural geology and geomechanics. Projects include geomechanical and stress modeling of petroleum reservoirs in Colorado, Wyoming, the North Sea, Indonesia and Colombia (geoscience.swri.org).

The second year of a multiyear joint industry project made major advances in understanding the role of faults in carbonate strata, important for characterizing and producing oil from major reservoirs around the world. The research site is instrumental in training global oil industry geologists, and information dissemination is aided by our local collaborator, the Guadalupe-Blanco River Authority (carbonatefaultproject.swri.org).

Our technical support to water resource management this year included studies of the Carrizo-Wilcox aquifer system, surface and ground water in Mexico, and water-related environmental issues in Wyoming. We continued to investigate the karst aquifer systems of south-central Texas and developed an updated groundwater availability model for the Barton Springs segment of the Edwards Aquifer (karst.swri.org).

In a multidivisional hydrogen research effort, we continued investigating the creation of alternative vehicle fuels from hydrogen-deficient feed stocks, such as coal.

Our expertise in terrestrial sciences is being applied to planetary programs, including developing and testing the MarsFlo code, a three-phase, two-component computer code to simulate hydrological processes in the subsurface of Mars. Other planetary programs include studying permafrost features on Earth to better understand Martian ice beds as well as investigating volcanic-tectonic interactions and analyzing and modeling landslides on Mars (planetarygeosciences.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.

1. *Using internal funding, we developed techniques to produce three-dimensional simulations for high-speed flow over a circular cylinder to validate multiscale hybrid turbulence models of fluid flow and heat transfer simulations in nuclear power reactor components.*

2. *Using laboratory experiments as well as numerical models, our scientists are investigating fluid movement through fissures and conduits that form in grouts used to isolate the radioactive waste contents of subsurface vaults and tanks from the environment.*

3. *We updated our physical analog laboratory, now outfitted with an SwRI-developed dynamic structured light measurement system, to investigate tectonic resurfacing processes on Jupiter's moon, Ganymede, and pit chain formation on Mars and the asteroid Eros as well as to support oil and gas geomechanical modeling activities.*

4. *Using wireless sensor networking developed through internal funding, SwRI scientists are mapping the limestone karst system surrounding Center Hill Dam near Cookeville, Tennessee. The karst system could affect the structural reliability of the dam, which provides hydroelectric power and flood control in central Tennessee.*

Signal Exploitation and Geolocation

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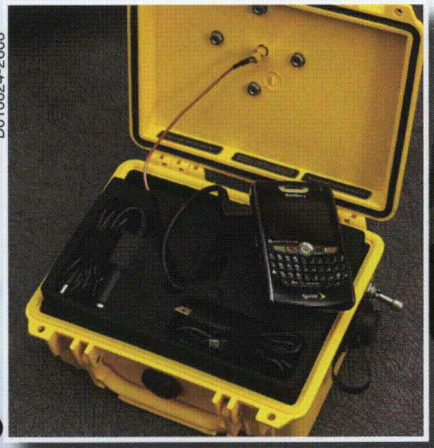

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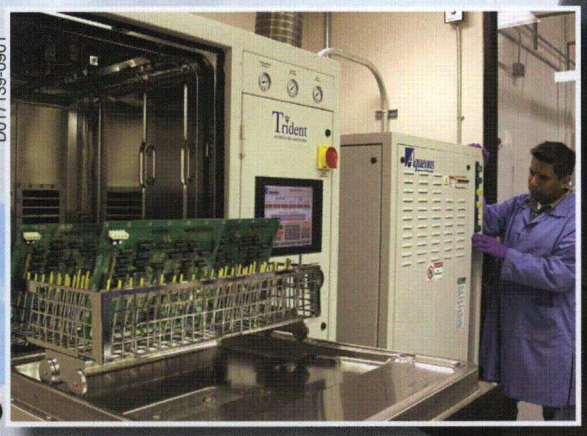

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Courtesy Lt. Col. Leslie Pratt, U.S. Air Force

D017219

3

We design shipboard and submarine antennas to withstand the rigors of the ocean. Prior to installation, staff members evaluate the direction finding performance of each antenna from atop a 73-foot tower to simulate its position on a ship.

D016927-2539

geolocation systems • intelligent SIGINT networks • wideband intercept • automatic signal recognition electromagnetic modeling & propagation analysis • system production • information exploitation tracking systems • spectrum surveillance • special-purpose tagging & tracking devices • steganalysis life-cycle support • repair & refurbishment • field engineering support • signal intelligence systems genetic programming • IFF

As a world leader in radio frequency signal exploitation and geolocation, Southwest Research Institute provides advanced systems to government, military and commercial clients. Our hardware and software solutions in signal intelligence, direction finding, communications and other areas help meet the challenging operational environments of clients worldwide.

In one of our longest-running programs, we continue to design and build antennas using innovative technologies for direction finding, communications and signal intercept applications (ad.swri.org). To meet increasing demands for conformal antennas, designed to blend into the surface and contours of the environment, we are designing new covert systems for vehicle, airborne and man-transportable applications.

We also are developing low-cost antennas made of novel materials to reduce size and weight that can be rapidly deployed and collapsed. These lightweight antennas use cloth and wire bodies to deploy with nearly the simplicity of opening an umbrella.

As of 2009, staff members have designed, built and delivered more than 150 composite antennas for shipboard applications (pod.swri.org). To improve the operation of our designs, we are extending the ranges of our antennas to operate at higher frequencies, up to 10 GHz. We also apply computational electromagnetic modeling techniques to optimize antenna locations, predict performance and reduce calibration time.

Using internal research funds, we are reducing the size, weight and power of VHF and UHF signals intelligence systems. Our approach uses field-programmable gate arrays on commercially available boards, enabling highly efficient data processing capabilities. The reduced size retains SwRI's proven SIGINT capabilities and allows for significantly smaller units to be used in a variety of tactical applications, including man-transportable, airborne and land-mobile operations (tse.swri.org).

We also are developing methods to automatically detect, process and record the copious amounts of data gathered by signals intelligence sensors. While many techniques can be used to lessen the volume of data, this approach can miss unknown threats. Staff members developing techniques to expand on this technology without reducing the volume of data. We also are evaluating various automated analysis tools to measure their effectiveness in finding high-value information in a timely manner.

Other internal research efforts are examining high-volume data collection and visualization methods and the use of pulsed radio frequency signals to estimate mobile ranges. Using internal funds to develop and prove new technologies creates less risk for our clients. For example, a client-funded electrical intelligence (ELINT) program originated as a situational awareness internal research effort.

We continue to make facility improvements to meet the needs of our clients. We reinforced our rotary test facility to accommodate the weight of armored vehicles as well as unmanned aerial vehicles, antennas and other electronic systems. We use this facility to evaluate the performance of antennas, for example, by placing a transmitter in a fixed location and then rotating the platform to measure antenna patterns or direction finding performance over 360 degrees.

Our design, development, testing and manufacturing services continue to meet high quality standards. Under our "Business Environment for Effective Management" system, which combines ISO and CMMI® standards into a single business method, we were re-certified to the latest ISO 9001:2008 standard. We also are implementing the Software Engineering Institute's CMMI Level 3 process to assure the highest quality for all signal exploitation and geolocation programs. ❖

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

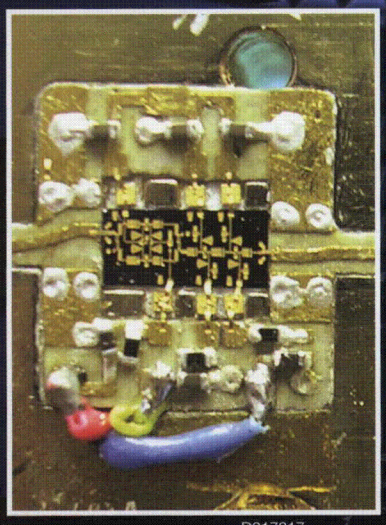
1. *The Civil Support for Enhanced Responsiveness system, sponsored by the Florida National Guard, is an emergency communications infrastructure to be used by units deployed following a disaster, such as a hurricane. Our engineers developed a component of the system (shown) that allows units to communicate with an operations center about inventory, alerts, commodity requests and other needs vital to recovery efforts. The system was successfully demonstrated to the Florida National Guard in February and exercised state-wide during the state of Florida annual hurricane preparedness exercise.*

2. *Staff members recently installed an aqueous cleaner that uses a safe, nonflammable, environmentally friendly wash solution to batch clean electronic components (sp.swri.org). The cleaner achieves results that exceed military, medical and other high-reliability cleanliness standards and reduces the probability of circuit board contamination.*

3. *SwRI engineers developed a radio communications relay for use aboard unmanned aerial vehicle platforms, such as the U.S. Air Force Predator (shown), to provide communications over an extended range (ss.swri.org). The system is compact and lightweight, requiring minimal power for operation.*

Applied Physics

SwRI is developing innovative metamaterial antennas that are smaller than conventional antennas of the same frequency. We evaluate these antennas in a 14-meter RF anechoic chamber to validate performance and optimize designs.



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digital & analog electronic systems development • RF systems • laser, fiber & electro-optics • sensors mechanical systems & design • acoustics & ultrasonics • reservoir characterization • biometric systems packaging • robotic vehicle evaluations • hardware & component analyses • advanced microelectronics microelectromechanical systems (MEMS) • rapid prototyping • miniaturization technologies

With a diverse staff and a full range of engineering facilities and expertise, Southwest Research Institute creates sophisticated, miniaturized, low-power electronic, sensor and optic systems and devices for a range of applications (applied-physics.swri.org). We also evaluate novel robot systems and develop new algorithms and software programs to collect and process data (advancedelectronics.swri.org).

To optimize reservoir production, petroleum companies rely on sophisticated analyses of geologic formations to assess rock permeability and porosity as well as volume and distribution of fractures, which provide pathways for hydrocarbon pooling and flow. Using existing borehole array processing algorithms, SwRI geophysicists have developed a new method for inverting cross-dipole sonic waveforms. The inversion algorithm quickly and reliably separates and extracts unknowns to accurately predict the number, distribution and direction of formation fractures, providing valuable clues for production-improving strategies, such as directional drilling from the original borehole outward into the formation (reservoirgeophysics.swri.org).

The Institute operates unique facilities to evaluate small unmanned ground robots. We continually expand the capacity and capability of our test bed facilities to keep up with the increasingly diverse and rapidly growing field of ground robotics. Recent additions include walls with a variety of surface features and textures to test climbing robots and a confined space used to evaluate snake-like robots. We also added an elevated arena with a motion capture system to track multiple communications relay robots.

In cooperation with SwRI antenna specialists, we used internal funding to study using metamaterials for radio frequency electromagnetic applications, including antenna and filter improvements. Electromagnetic metamaterials are composed of a host medium with inclusions designed to control electromagnetic radiation properties. To fit in tight spaces, we developed a patch antenna about one-fifth the size of a normal system that offers two resonant frequencies, one characteristic of the patch and one related to the resonance of the enclosed metamaterial. The metamaterial load provides lower frequency resonance and, as the size of the patch is decreased, the lower resonant frequency also decreases (advancedelectronics.swri.org).

Our high-frequency millimeter wave designs draw from multiple disciplines. By applying advanced design methods, including finite element modeling and microwave cascade circuit optimization, in concert with state-of-the-art assembly equipment, we are developing advanced microwave monolithic integrated circuit, or MMIC, designs such as a 35-GHz amplified detector for a passive millimeter-wave imaging system. Staff members also led an internal research project to expand detector capabilities up to 110 GHz in support of current and future program initiatives.

We are developing a unique automated pedestrian system to test the response of autonomous vehicle safety and perception systems without endangering a real person. Using advanced analytical tools to model the dynamics of the system, SwRI is working to achieve stable balancing and to coordinate walking speed with cadence. ❖

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

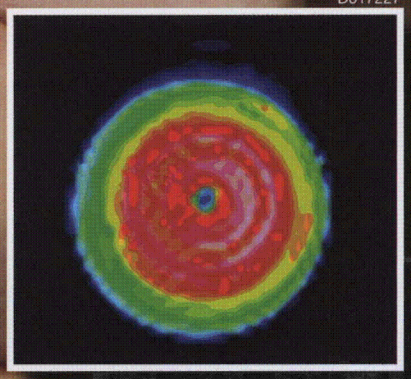
1. *Combining finite element modeling and microwave cascade circuit optimization with advanced design capabilities and state-of-the-art assembly equipment, SwRI developed advanced microwave monolithic integrated circuit designs, including a 35-GHz amplified detector for a passive millimeter-wave imaging system. Using internal funding, we continue to advance our capabilities to create detectors in the 110-GHz range (advancedelectronics.swri.org).*

2. *In 2009, we conducted tests and experiments to evaluate small unmanned ground robots in the extremely challenging environment of the Mojave Desert in California.*

3. *To read the formations surrounding petroleum deposits, SwRI geophysicists have created a new algorithm that uses cross-dipole sonic data to estimate formation properties around boreholes.*

Chemistry and Chemical Engineering

A new pyrolysis combustion flow calorimeter allows SwRI fire specialists to cost-effectively evaluate the ignition and heat release rate characteristics of various plastics using milligram-sized specimens.



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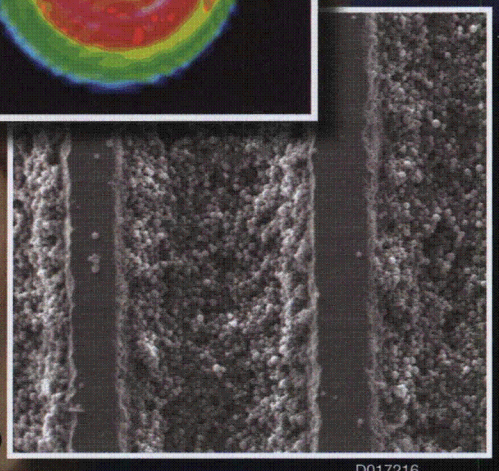

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environmental engineering • materials chemistry • process engineering • fire protection engineering demilitarization • analytical & environmental chemistry • pharmaceutical chemistry • homeland security environmental sampling • analytical methods development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

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

In the case of terrorist chemical attacks, it is critical to quickly identify and pinpoint whether explosives or chemicals were manufactured in foreign states or in domestic clandestine laboratories. SwRI is developing new hyperabsorptive sampling materials and new forensics techniques to correlate chemical signatures with specific geographical regions or, in some cases, a specific manufacturer. Other ongoing programs utilize high-resolution mass spectroscopy and gas and liquid chromatography to survey air, soil, water and other matrices for the presence of chemical warfare agent decomposition signatures at levels in the parts per trillion.*

SwRI continues to support programs to destroy the nation's chemical agent stockpiles, including the final closure of the Newport, Ind., demilitarization plant. San Antonio laboratory personnel analyze samples at each stage of closure to ensure no residual chemical agent or toxic decomposition products are present prior to release of facility equipment and buildings. Pine Bluff, Ark., and Umatilla, Ore., chemical agent disposal facilities completed destruction of VX and sarin nerve agents and began destruction of the final chemical agent, mustard-based blister gas.

SwRI chemists and scientists provide a spectrum of services to assess food safety and quality for the entire food industry, from the farm to the fork. SwRI implemented dispersive solid-phase extraction techniques, which allow for sample extraction and interferent cleanup in fewer steps, using less solvent, to analyze complex food samples more quickly while reducing laboratory costs and waste.

For more than 60 years, we have advanced the state of the art in micro- and nano-encapsulation technologies for applications in the personal care, food, pharmaceutical and other consumer product industries (microencapsulation.swri.org). We are developing the next generation of countermeasures for chemical defense, applying micro- and nano-stabilization technologies to improve chemical weapons antidotes and biological defense-related therapeutics (drugdelivery.swri.org). These include developing a pipeline of therapeutic countermeasures as well as clinical supplies of therapeutics. Beyond particle-based drug delivery, SwRI is also creating drug-eluting materials that can be used as coatings or scaffolds and promising new treatments for bone fractures.

To help the fire protection community accurately model fire growth in enclosures, SwRI fire specialists are helping the National Institute of Standards and Technology develop a guide for obtaining ignition, flame spread, burning rate, combustion products and thermophysical material properties. SwRI scientists are also evaluating the ignition and explosion hazards of hydrogen leaks from a fuel-cell powered vehicle in a residential garage. The ignition source in these tests represents an electrical fault in a garage door opener. The data will be used to validate computer models developed by NIST to simulate the dispersion of hydrogen and predict ignition and the effects of an explosion. To help the military meet Environmental Protection Agency reporting requirements, SwRI also conducted a series of large pool fire tests to determine the emissions associated with extended burns of JP-8 aviation fuel (fire.swri.org).

To support the energy industry, the Institute is operating a large outdoor pilot plant that converts natural gas to useful hydrocarbon liquids and is developing process safety management protocols for facility operations. We also developed a process to reclaim ethylene glycol used for flow assurance in long-distance gas transmission pipelines. ❖

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

1. *SwRI is developing novel sorbent-coated etched rolled films, providing a high-surface-area, low-pressure-drop platform to sample atmospheric impurities in concentrations ranging from 100 parts per million to 10 parts per trillion. Several coated SCERFS stacked in tubes provide a multi-adsorptive material approach, capturing a wide range of analytes, which can be rapidly extracted by resistively heating the SCERFs (inset).**

2. *In 2009, we developed and manufactured a Phase I chemotherapeutic drug and prepared key intermediates for later-phase drug trials in our cGMP facilities. We also developed capsules, a drug releasing implant and a lyophilized injectable product.*

3. *SwRI recently commissioned this heavy oil upgrade test facility to evaluate converting heavy or residual petroleum into high-quality synthetic crude oil.*

*DOD Distribution Statement A: Approved for public release; distribution is unlimited.

Consolidated Financial Statements

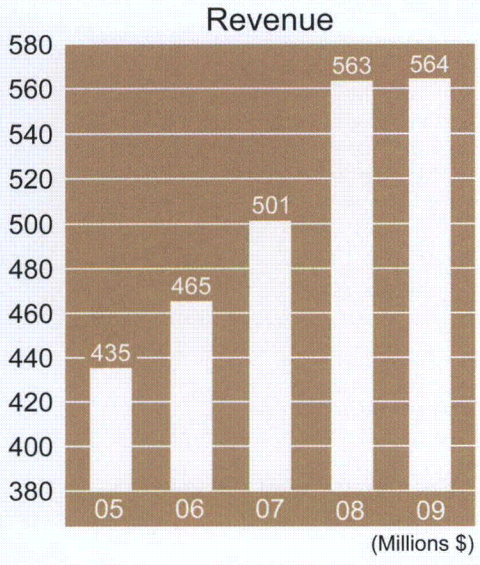
For the years ended September 25, 2009, and September 26, 2008

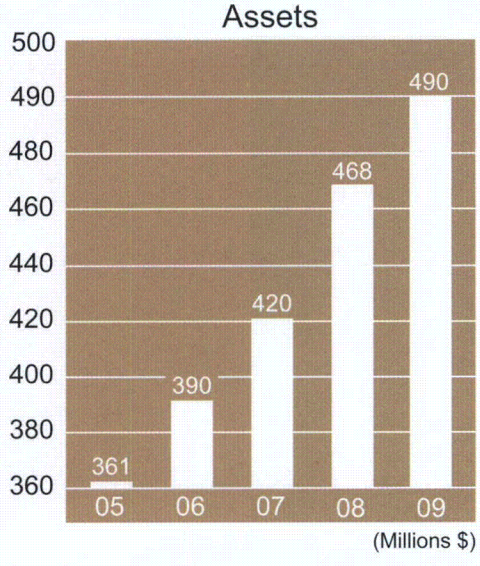
Income Statements (in thousands of dollars)

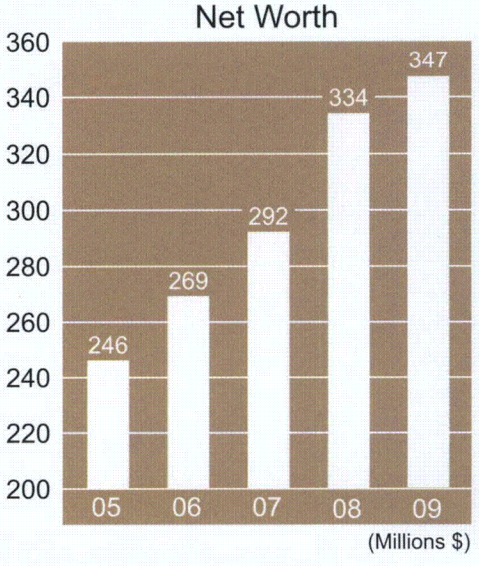
	2009	2008
Revenue	$563,854	$563,137
Direct Project Costs	337,432	338,144
Operating Income	226,422	224,993
Division Operating Expenses	124,943	117,645
General Overhead	57,373	46,741
Depreciation — General Facilities	13,505	12,897
Internal Research	8,711	6,972
Realized/Unrealized (Gain) Loss on Postretirement Medical Funds	(1,094)	4,373
Income Before Federal Income Tax Expense	22,984	36,365
Federal Income Tax Expense	(57)	(370)
Net Income	$22,927	$35,995

Balance Sheets (in thousands of dollars)

	2009	2008
Current Assets	$190,685	$185,340
Property and Equipment, Net	256,834	244,724
Other Assets	42,819	37,655
Total Assets	$490,338	$467,719
Current Liabilities	$76,579	$76,525
Noncurrent Liabilities	66,768	57,108
Net Worth	346,991	334,086
Total Liabilities and Net Worth	$490,338	$467,719







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