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Sandia National Laboratories

LABS ACCOMPLISHMENTS

Sandia LabNews

MARCH 2012

On Oct. 25, 2011, NNSA announced that the last B53 nuclear bomb, the oldest weapon in America's arsenal and one of the largest in US history, had been dismantled 12 months ahead of schedule. A team of Sandia researchers was honored with a Secretarial Achievement Award, which recognizes employees whose performance exceeds the call of duty, for its part in implementing the B53 dismantlement process with strict efficiency and safety standards (see page 3).

The B53 bomb was designed by Los Alamos National Laboratory and Sandia. After being introduced into the stockpile in 1962, the B53 served a key role in America's nuclear deterrent until its retirement in 1997. The B53 bomb is one of the longest-lived and highest-yield nuclear weapons ever fielded. Its sheer size and weight provided many challenges for the project team responsible for developing a dismantlement program that met NNSA's rigorous requirements.

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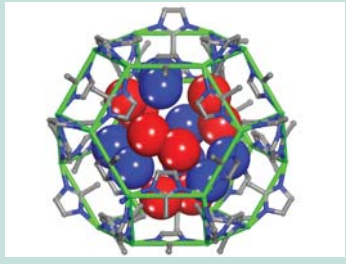

Sandia post-doctoral fellow Carlee Ashley introduces a buffer into a protocell solution to dilute it. Melding nanotechnology and medical research, Sandia, the University of New Mexico, and the UNM Cancer Research and Treatment Center have produced an effective strategy that uses nanoparticles to blast cancerous cells with a mélange of killer drugs.

Cover photograph by Randy Montoya

This year's *Labs Accomplishments* publication recognizes some of Sandia's best work during 2011, as submitted by center offices and selected by division offices. Each citation is followed by the numbers of centers that contributed most directly to the effort described.

An acronym after each accomplishment indicates which of Sandia's strategic management units (SMUs) the work most directly supported. The SMU acronyms are:

NW: Nuclear Weapons SMU
DS&A: Defense Systems & Assessments SMU
IHNS: International, Homeland, & Nuclear Security SMU
ECIS: Energy, Climate, & Infrastructure SMU
IMS: Integrated Mission Support SMU

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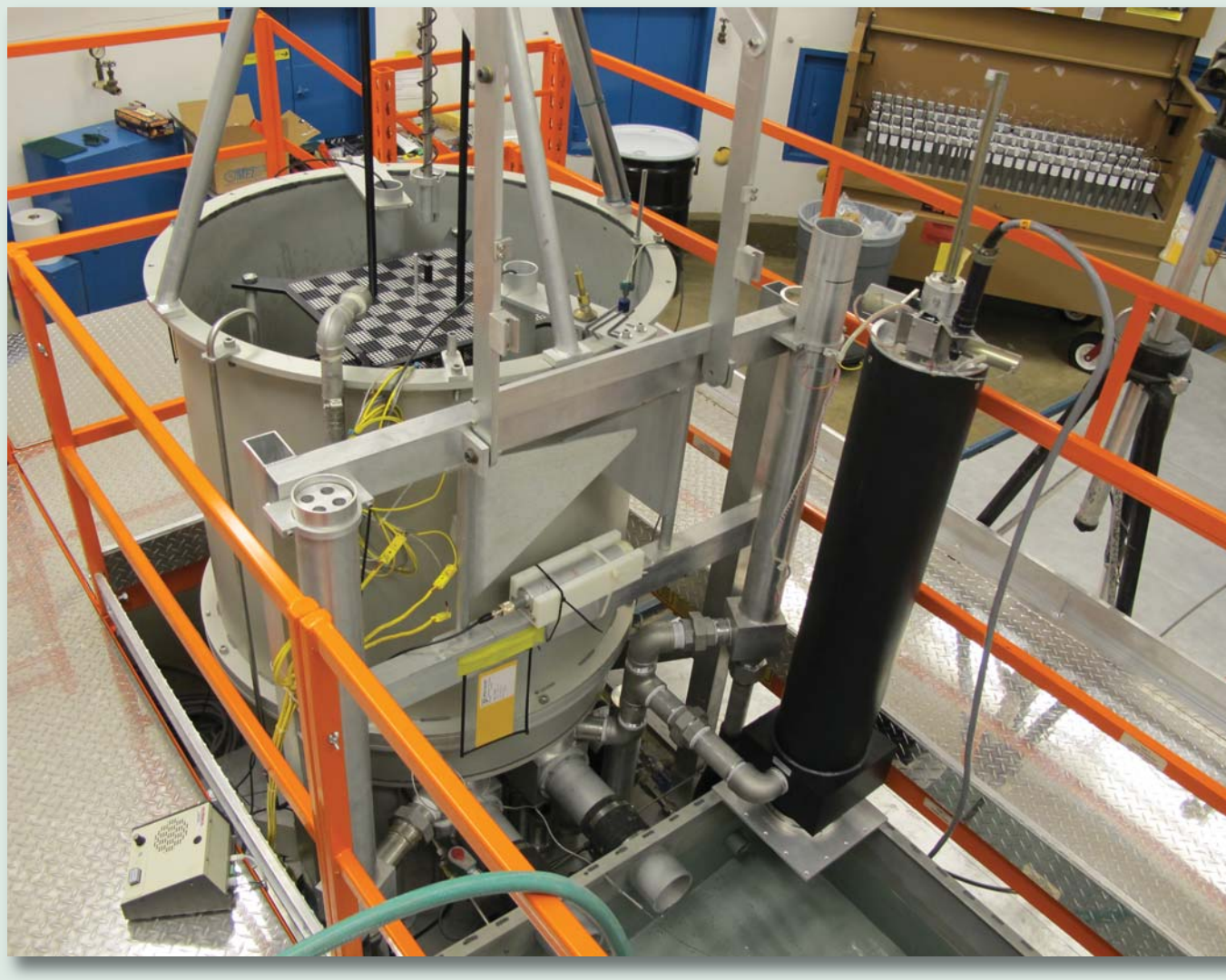
Sandia National Laboratories

Sandia National Laboratories is a multiprogram laboratory operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corp., for the US Department of Energy's National Nuclear Security Administration.

Nuclear weapons engineering

As part of the development of a reactor experiments training course for the National Nuclear Security Administration (NNSA), **Sandia upgraded the critical assembly (a small nuclear reactor) in Tech Area 5 to permit a new class of experiments.** Hardware was designed and installed that allows experiments to safely approach critical conditions by varying the amount of water in the assembly. This provides the capability to simulate a criticality accident caused by flooding, something that is at the heart of many safety analyses for the storage of nuclear material across the DOE enterprise. (1300, 2900) NW



The upgraded hardware (the large black cylinder to the right) that permits criticality experiments by varying the amount of water in the reactor is shown installed on the Sandia critical assembly in Tech Area 5.

Operating on a compressed schedule and with ongoing changes in scope, the B61 Life Extension Program (LEP) team completed Phase 6.2 and 6.2A weapon development activities. Major milestones in these activities included the Phase 6.2 design review, Integrated Phase Gates B and C, the Weapons Design and Cost Report (WDCR), and Phase 6.2/6.2A report. **These activities were delivered on schedule to NNSA and culminated in the request for Phase 6.3 authorization to the Nuclear Weapons Council (NWC) in November.** (0400, 1100, 1500, 1600, 1700, 1800, 2100, 2500, 2600, 2700, 2900, 5300, 5400, 5600, 5700, 5900, 6900, 8100, 8200, 8500, 8900, 9500, 10600) NW

Dismantlement of the last B53 bomb was safely and securely accomplished a year ahead of schedule. Sandia provided significant technical contributions to enable dismantlement of the oldest and largest weapon in the US stockpile, including structural testing and analysis of the aged composite material, which provided Pantex with essential weapon response information to safely move and dismantle the last two B53 subassemblies. The B53 Weapon System Dismantlement Team was awarded the 2011 Secretary of Energy's Achievement Award. (2111, 412, 432, 433, 431, 411, 421, 1524, 1822, 2132, 2913) NW

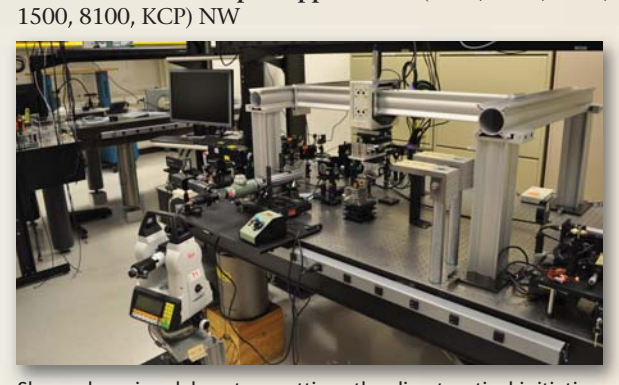
The Nuclear Enterprise Assurance (NEA) team established the organizational and procedural basis at Sandia and within the Nuclear Security Enterprise for identifying and mitigating cyber and supply chain vulnerabilities. The effort established the core integration approach as well as processes and tools from the four major Sandia "pillars" including vulnerability analysis, threat analysis, mitigation options development, and trusted implementations. The NEA team also established a key partnership with the Kansas City Plant, creating a working group that has mapped out the combined NEA approach between the two organizations. **This partnership has provided the basis upon which NNSA is building its NEA approach, with Sandia as a key leader in the enterprise-wide effort.** Analyses have been completed on select weapon components, as well as critical Sandia infrastructure in joint efforts with their parent organizations. (2100, 2300, 5600, 5900, 1700, 9300, 9500, 2600, 2700) NW

Researchers in the Explosives Technologies Group are vapor-depositing explosives to study detonation behavior at sub-millimeter length-scales. Recent work has shown that the explosive PETN (pentaerythritol tetranitrate) has a detonation failure thickness roughly the width of a human hair. Despite the importance of PETN, this critical material performance property was unknown until Sandia developed this novel experimental technique. Research on explosives at these geometries has implications for understanding not only explosive failure, but also initiation and geometrical effects on detonation. (1800, 2500) NW

Photograph of Sandia's critical thickness experiment used to determine the thickness at which detonations fail in deposited explosives. Optical fibers are used to track the position of the detonation wave. This experiment typically uses less explosive material than the size of one-tenth of an aspirin tablet.

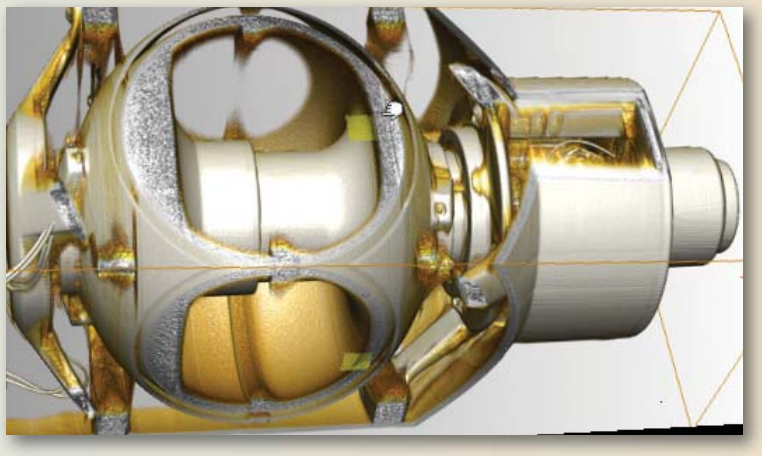
An electrical prototype of the Direct Optical Initiation Firing Set has been successfully demonstrated to be at a Technology Readiness Level 4: prototype validated in a laboratory environment. Key interface performance requirements were met using a commercially manufactured laser whose design was realized through investments in multiple Sandia science and technology areas. **The laser and beam conditioning optics represent a major step toward simplifying this technology into a manufacturable firing set for a nuclear weapon application.** (2600, 1100, 5700, 1500, 8100, KCP) NW

Members of Sandia's B53 Dismantlement Team, who were recently honored with a DOE Secretarial Achievement Award, stand beside a B53 weapon casing in the display yard at the National Museum of Nuclear Science & History.
(Photo by Randy Montoya)



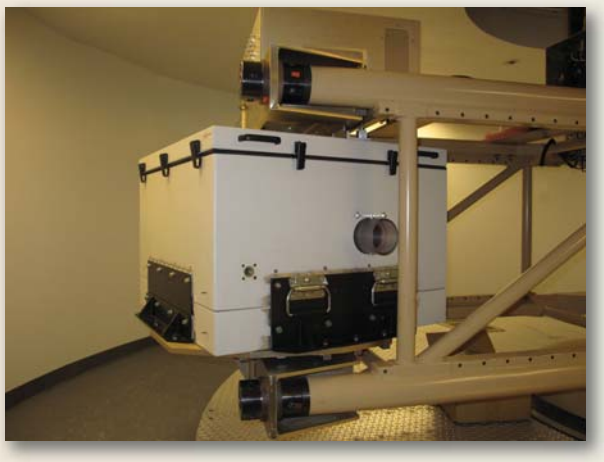
Shown here in a laboratory setting, the direct optical initiation breadboard test setup employs a commercially manufactured laser to create a more simplified firing set.

The Tritium Thermoelectric Generator (TTG) team demonstrated a fully integrated prototype milliwatt power supply with a resistive heat source. Several prototypes were built and extensively tested. **This completed a significant engineering effort including end-to-end subcomponent simulation, prototyping, and testing.** Component maturation is on an aggressive schedule and risk is reduced through a combination of engineering development, performance and environmental testing, materials characterization, and multiphysics simulations involving personnel from various centers across Sandia and from other NNSA sites. (2500, 8200, 1500, 8100, 8300, 8600, 1800, KCP, SRL) NW



This CT scan shows the internal structure of a Sandia-fabricated TTG prototype.

The Weapon Evaluation Test Laboratory executed more than 1,000 surveillance tests during FY11, including 59 weapon system tests, more than doubling recent test rates. This was accomplished while starting up a new system tester, upgrading several testers, and addressing deferred test equipment maintenance. Growing demands for information continue to increase test complexity, but the introduction of new capabilities, improved planning tools, and improved process flows enabled this stellar test record. The data from these tests contribute to the Annual Assessment of the stockpile. (2900, 400, 2100, 8200) NW



The W80 test unit in an environmental chamber preparing for launch simulation on a WETL centrifuge.

Sandia explosives researchers have used density functional theory (DFT), a quantum mechanical modeling method, to predict the behavior of explosives at extreme pressures and temperatures. The theoretically derived shock Hugoniot (including temperature predictions), compression isotherm, specific heat, and other thermodynamic parameters provide knowledge of the full equation of state, something that is often immensely difficult or impossible to achieve empirically. **As such, these data are invaluable to the engineering scientists tasked with providing responsive design, Quantification of Margins & Uncertainties, and predictive hydrocode simulations of new explosive components.** (2555, 1443, 1641) NW

The Weapons System Engineering Assessment Technology program has completed the level 2 milestone, Organic Decomposition and Breach of Safety-Related Sealed Exclusion Regions in Abnormal Thermal Environments. **Sandia concluded and documented the experimental validation of weapon interior breach scenarios resulting from abnormal thermal environments.** These data will be used to validate modeling of these breaches in fire environments resulting from accidents involving nuclear weapons. (8200, 1500) NW

Sandia began the Phase 6.2/6.2A Conceptual Design and Cost study to develop a replacement arming, fuzing, and firing (AF&F) system for the Navy Mk5/W88 reentry system. The project, known as the W88 Alt. 370, has the key mission to develop an AF&F system suitable for use in the Navy Mk5/W88-0 that can also be adapted for use in the Air Force Mk21/W87 and Mk12A/W78-1 life extension programs. **Key FY11 accomplishments include the completion of major design trade studies, establishment of baseline requirements, and development of an early conceptual design.** (0200, 2100, 2500, 2600, 2900, 5300) NW

W88 Alt. 370 AF&F conceptual design.

Members of Weapons Controller Dept. 5351 successfully completed the development of advanced arming and fuzing concepts in collaboration with the Atomic Weapons Establishment of the United Kingdom. **This team designed, developed, and produced a subsystem prototype that demonstrated key technologies needed for next-generation reentry system controllers.** This project helped reduce the risk, time, and cost for the upcoming refurbishments. The new architecture allows a similar controller to be applied to both Navy and Air Force reentry systems. (5300) NW

Sandia's Integrated Lifecycle Security (ILS) project developed a methodology and tool set to assess the state of security across the nuclear weapon stockpile and to evaluate the effectiveness of potential security improvement proposals. **ILS was recently selected by NNSA as the basis for a common enterprise-wide approach to evaluating stockpile risk.** Sandia is now engaging with NNSA, LANL, LLNL, and elements of the DoD to perform a comprehensive security risk assessment, which is intended to inform national weapons policy and planning decision makers. (0200, 0400, 2100, 5600, 5900, 6600, 8100, 8200) NW

Sandia is continuing its efforts to ensure a sustainable flight test capability at Tonopah Test Range (TTR). **In 2011, TTR successfully executed 12 flight and ground tests while evaluating opportunities to leverage Air Force capabilities.** As part of our effort to improve TTR's operational model, physical security responsibility was transferred to the USAF, effective Oct. 1, 2011, at a cost-savings to Sandia of approximately $3 million a year and a security footprint reduction of more than 90 percent. (2900, 4200) NW

A B61 flight test.

Following a Senior Management Panel Review of the Sandia Weapon Intern Program (WIP) in December 2010, WIP has been restructured to meet current and evolving nuclear deterrence workforce needs of the nation. The new program reduces Sandia interns' time away from their regular assignment to six months, after which they work on a line project for the next five months. **The restructured program has been implemented with the 2012 class, which has participants from eight other nuclear security enterprise sites, in addition to Sandia/New Mexico and Sandia/California.** (2900) NW

Weapon security

The Air Force and its stakeholders engaged Sandia on many projects this year for the purpose of more securely protecting critical assets on military installations worldwide. **Sandia provided security analyses, engineering, design, and testing, and oversaw procurement and installation of security upgrades.** Air Force bases that have received support from Sandia include F.E. Warren, Malmstrom, Minot, Whiteman, Kirtland, and six other US and NATO installations. Sandia continues to broaden its reputation and impact in protecting our nation's most critical assets through a science-based, systems engineering approach to security. (6510) IHNS

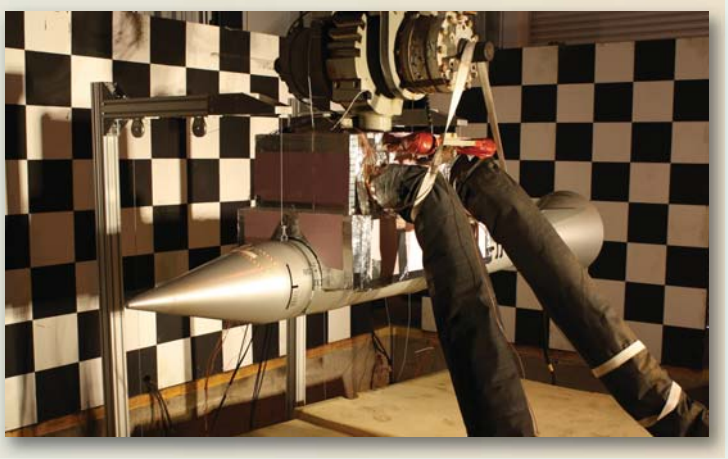
On Oct. 27, 2011, the US Navy formally accepted turnover of operational control of a state-of-the-art waterfront perimeter security system designed, installed, and thoroughly tested by Sandia. **This milestone marks the successful completion of the first phase of a multiyear design and development effort to field a robust, fully integrated high-security system** at high-profile US Navy facilities. For their efforts, the Sandia design team was rewarded with a team Employee Recognition Award. (6520) IHNS

The Transportation Safeguards and Surety Program completed design qualification of the OPUS Project hardware, which is in production and scheduled for deployment in summer 2012. The primary hardware includes an Overpack for weapon transportation in the SafeGuards Transporter. **The project team received NNSA's Award of Excellence for this innovative solution for improving the safety, security, and logistics of the over-the-road transportation operation for the nation's containerized nuclear explosives.** (6600) NW

OPUS Overpack.

The Ion Beam Laboratory (IBL) is a successful capital construction ($39.6 million) project completed six months ahead of schedule and $5.5 million under budget. **The IBL achieved Leadership in Energy & Environmental Design (LEED®) gold certification for environmental excellence and a zero-injury safety record.** The facility provides capability for performing ion beam irradiations at energies from a few to nearly a billion electron volts. The building was designed to support the equipment so well that significant benefits of increased space utilization were achieved. (4800, 1100) NW

A cross-organization team lead by the Aircraft Compatibility organization successfully conducted a static ejection test series to evaluate structural response environments on gravity bomb systems from the ejection rack of a B-2A aircraft at Eglin Air Force Base. The data from this test series will allow Sandia to certify the gravity bomb systems for a new ejector cartridge, and for the first time, evaluate multiple unknown effects from the ejection rack onto the bombs. (0400, 1500, 2100, 2900 and 8200) NW



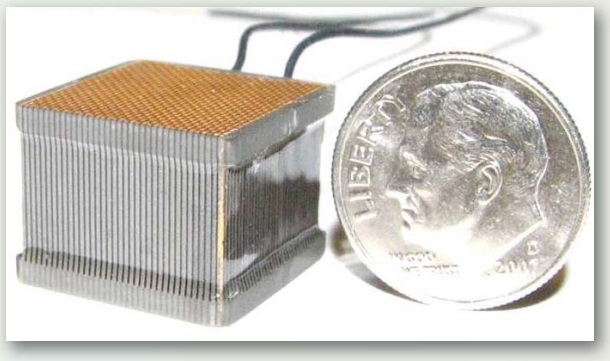
B61-11 instrumented test unit and temperature-conditioned ejection rack.

Remote sensing

A Class III UAV outfitted with a Sandia-developed SAR.

Sandia-developed synthetic aperture radars (SAR) are fielded on unmanned aerial vehicles to locate and help defeat improvised explosive devices (IEDs). **This system was unanimously recommended as a proven counter-IED system by the Department of Defense.** The following quote demonstrates this system's impact: "That thing is amazing. I wish we had it from the beginning; a lot of people would still be around right now. I have witnessed two occasions… where things could have turned out bad and you all saved the day." (5300) DS&A

Zero maintenance, out-of-sight, continuous power is required for many remote-sensing applications. To meet this need, **Sandia's Power Source Technology Group developed a buried energy harvester that converts diurnal heat flow through the upper soil layer into electricity.** The device uses power management circuitry, aerogel insulation, and more than 5,000 thermoelectric elements to maximize efficiency and voltage from small temperature differences. One year of continuous field testing confirmed simulations predicting milliwatts of continuous power. (2500, 1500, 8200, Jet Propulsion Laboratory, and Marlow Industries) DS&A



An example of a custom thermopile.

For nearly 50 years NNSA, its predecessors, and the US Air Force have jointly developed and launched satellite sensor systems designed to detect atmospheric and space nuclear detonations (NUDETs). On July 16, 2011, the second payload of the next-generation sensor systems was launched on a Global Positioning System satellite. T**his new generation of sensor systems is designed to significantly enhance the nation's ability to monitor nuclear treaty compliance over the entire planet**, 24 hours a day, 365 days a year. Over the next 10 years, researchers will be launching 18 more next-gen sensors. (5700, 1500, 1700, 1800, 2600, 5300, 5500) DS&A

Launch of GPS satellite IIF-2, July 16, 2011.

Sandia has developed new infrared photodetector technology that dramatically enhances the sensitivity and resolution of mid-infrared focal-plane arrays used in tactical and strategic sensors. This achievement is based on a unique novel device architecture that suppresses inherent dark current mechanisms and was enabled by accompanying advances in devices physics and semiconductor material science. Large-format focal plane arrays were recently made at Sandia and demonstrated to various interested agencies. The research continues on developing multi-color capability and chip-scale photonic integration to enable additional functionalities. (1700, 1100, 5700) DS&A

Several agencies are developing a Technical Nuclear Forensics capability with various measurements to determine technical information about a terrorist nuclear weapon that might be detonated in a city. Yield is an important parameter that might be determined by comparing measured and simulated signals from optical sensors. A proof-of-concept exercise was completed in which a "red" team prepared simulated signals from a detonation near Madison Square Garden and a "blue" team **successfully determined the yield and location by varying inputs to Sandia simulation tools.** (5700, 0200, 6600, 9300) DS&A

Fostering game-changing technical solutions for today's warfighter, the **Tagging, Tracking, and Locating (TTL) Grand Challenge LDRD was successfully completed with numerous technical achievements and real-world system demonstrations.** Led by Center 5300 with major contributions from Center 1700 and the University of Illinois at Urbana-Champaign, the TTL Grand Challenge team authored novel radio-frequency (RF) communications algorithms, produced state-of-the-art MEMS microresonators critical for device miniaturization, developed new placement-insensitive and embedded antennas, and demonstrated both wide-area search and high-fidelity location in a single device. The TTL Grand Challenge generated significant intellectual property and contributed to a 2011 R&D 100 Award for MEMS microresonator technology. Numerous technologies developed by the TTL team have propagated into real-world solutions across a broad range of US government applications. (1700, 5300) DS&A

MEMS Microresonators

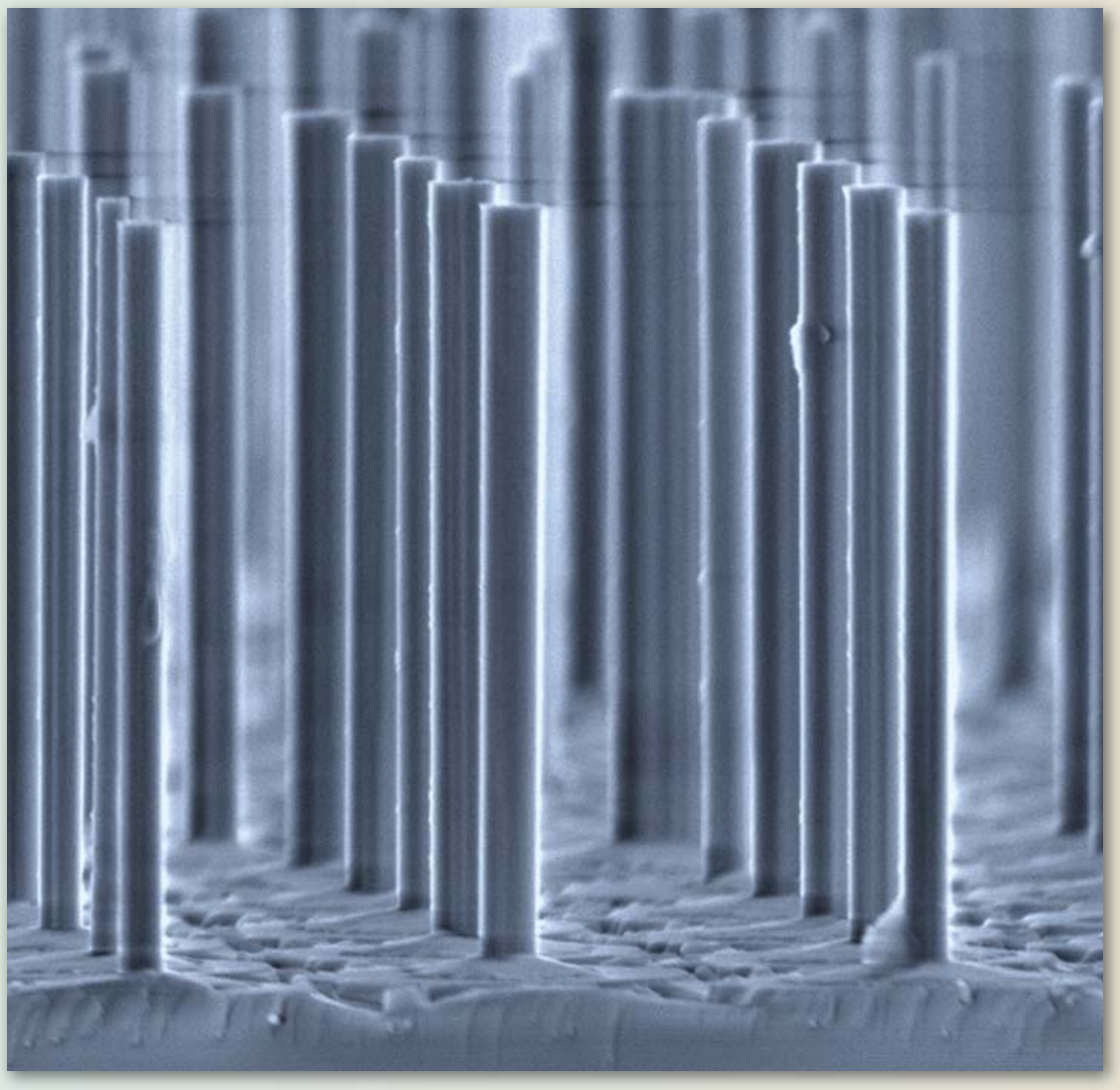
Funded through the American Recovery and Reinvestment Act, Sandia completed $5 million in projects at the DOE Atmospheric Radiation Measurement facilities in Alaska, Oklahoma, and Darwin, Australia. Sandia designed and developed climate research instruments and infrastructure, racing to finish installation in Barrow, Alaska, this September as North Slope winter weather arrived. Instruments include a scanning precipitation radar, scanning cloud radar, automatic balloon launcher, high-spectral-resolution Light Detection And Ranging (LIDAR), and extended range atmospheric emitted radiance interferometer. **These instruments are providing researchers an unprecedented, long-term, three-dimensional view of the arctic and tropical atmospheres.** (6900, 8100) ECIS

A newly installed X-band scanning ARM precipitation radar operates from atop the Barrow Arctic Research Center.

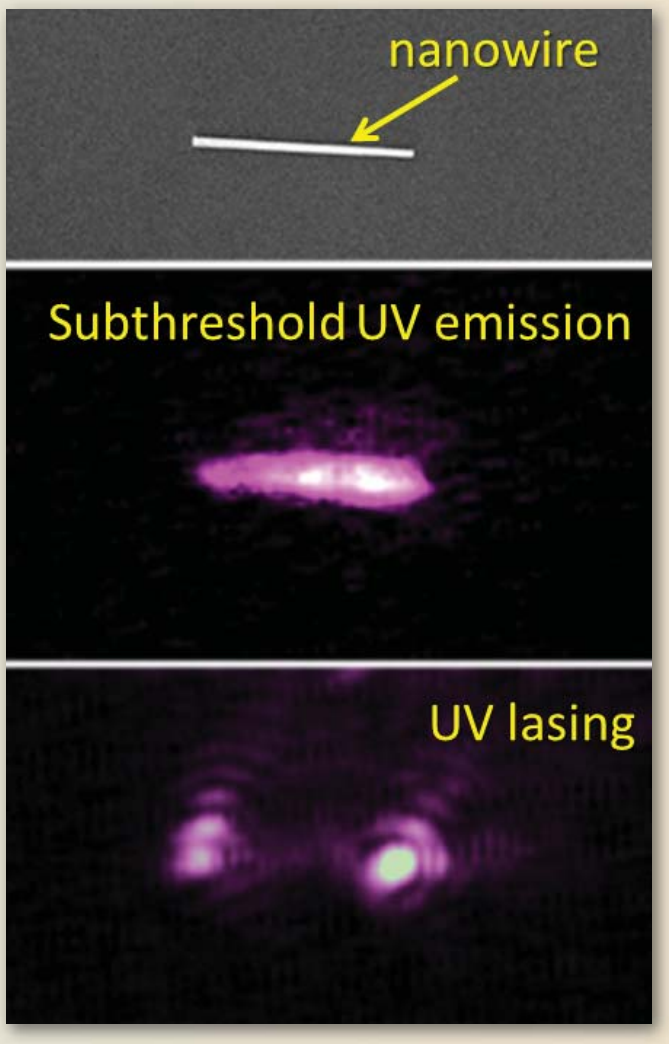
Working with NASA, the Sandia LDRI Orbiter Inspection System (LOIS) team provided critical life safety inspections of the Space Shuttle on orbit during each flight post *Columbia*. This specialized capability was developed rapidly to allow NASA to return to flight in support of the International Space Station. **The Sandia team was on console in Mission Control Center Houston for all 22 missions including the historic last shuttle mission.** The team provided support, yielding perfect mission success. Like all successes, this required great personal sacrifice from the team. (5700) DS&A

An astronaut during Mission 131 pointing through the window on Space Shuttle *Atlantis* at the Sandia LDRI sensor on the Orbiter Boom Sensor System. (Photo Courtesy NASA)

Materials



An array of GaN nanowires.



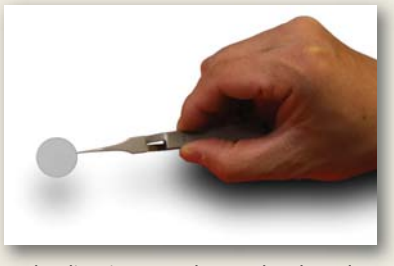
Single GaN nanowire (top), subthreshold UV emission from nanowire (middle), above-threshold UV lasing from nanowire ends (bottom).

The development of nanolasers could enable ultra-compact, low-threshold, and coherent light sources for a variety of applications. Nanowires are ideal candidates for nanolasers as they inherently function as a gain media, waveguide, and optical cavity. Sandia researchers have developed a fabrication process for creating optically pumped gallium nitride (GaN) nanowire UV lasers with precisely controllable diameters. These nanowires are found to exhibit single-mode lasing without the need for complex reflective gratings, **potentially enabling a new class of nanolasers with ultra-narrow line widths and low noise.** (1100, 1700) ECIS

A new adhesion layer for metallization of silicon substrates using zinc oxide thin films has been identified. By using ZnO to adhere metal films to silicon substrates, preparation of thin films with unparalleled properties and chemical homogeneity has been achieved, owing to greatly enhanced metal wetting properties. **This has resulted in the highest known dielectric response of a $BaTiO_3$ film and highest ferroelectric response** of a lead zirconate titanate film on silicon substrates and may have substantial impacts on piezoelectric and capacitor applications. (1800) DS&A

Wireless communication systems must operate reliably over a range of temperatures; however, temperature-induced changes in material properties can shift the resonant frequency and degrade or destroy wireless device performance. Sandia has developed and is patenting a novel materials approach to compensate for such temperature effects in multilayer, ceramic-based, 3-D microelectronic circuits. This new technology provides nearly constant device operation over a wide temperature range. **Beyond Sandia's internal needs, this innovative technology could also benefit radio and microwave applications in the wireless communication industry.** (1800) DS&A

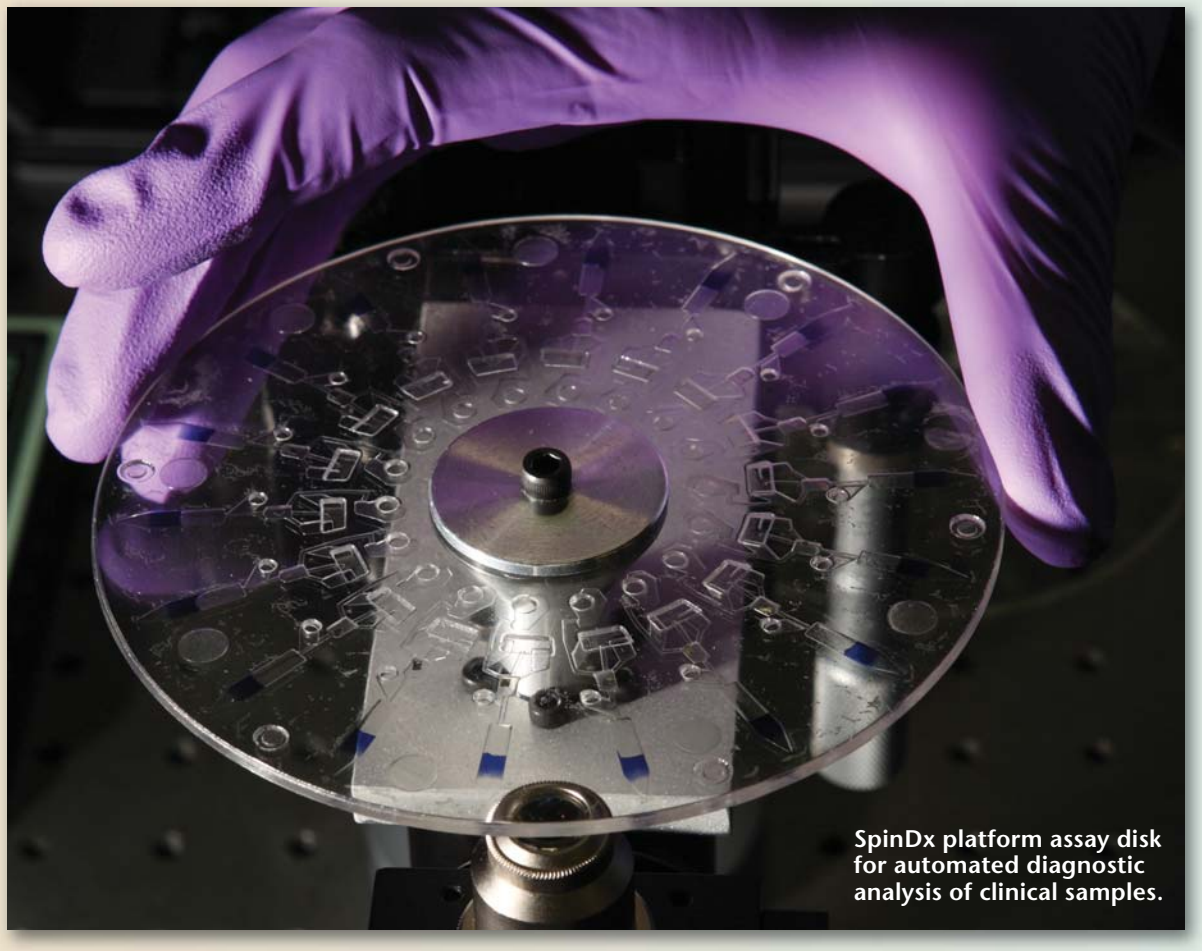
Sandia researchers (Susan Rempe, David Rogers, Kevin Leung, and Jeff Brinker), along with colleagues at the University of New Mexico (Ying-Bing Jiang) received a 2011 R&D100 Award for developing a novel class of desalination membranes that mark a significant improvement over reverse osmosis (RO) membranes. The nanoporous material has twice the efficiency of an RO membrane because it has high salt rejection and improved water flux (the rate at which water permeates a membrane), even at pressures as low as 80 pounds per square inch. **This breakthrough in material design means that it is possible to produce ultra-low-pressure nanofiltration and RO water purification** membranes that are highly efficient, representing a significant savings in energy costs. (8600, 1100, 1000) ST&E



A desalination membrane developed at Sandia.

Bioscience

SpinDx is an innovative and versatile diagnostics platform developed under LDRD and NIH funding for conducting multiplexed immunoassays and cellular assays at the point-of-care with unprecedented sensitivity, speed, and ease-of-use over commercial systems. While initially developed for fieldable radiation biodosimetry scenarios, SpinDx has broad applicability, including toxin diagnostics, bacterial and viral pathogen detection, and for detecting biomarkers of other systemic diseases. The patent-pending, fully automated platform has significant commercial interest due to its compatibility with myriad sample types including blood, saliva, foods, and environmental samples with no sample preparation required and with ultrasensitive detection limits. (8600) IHNS



SpinDx platform assay disk for automated diagnostic analysis of clinical samples.

IT, networks, & facilities

Nuclear Weapons, Facilities, and Procurement **co-located the majority of the B61 Life Extension Program team in the heart of the "Innovation Corridor"** of the Sandia/New Mexico campus. Renovation and space-consolidation projects in numerous buildings, along with a new lease for the Cyber Engineering Research Institute, allowed Facilities to free up contiguous space for 100 people on the B61 team to work and interact more efficiently. (1400, 1500, 2100, 4800, 10200) NW, IMS

In October 2011, the Sandia/California Combustion Research Computation Visualization facility (CRCV) received the Leadership in Environmental and Energy Design (LEED®) Gold certification for new construction from the US Green Building Council. LEED is an internationally recognized certification standard that promotes sustainable building and development practices. Using an integrated design approach between the contractor, architect, and Sandia, **the CRCV building systems were optimized to use 20 percent less energy and 40 percent less water on an annual basis over the industry standards for similar facilities.** (8500, 8300, 4100, 4800) ECIS

In October 2011, the Combustion Research Computation Visualization facility received LEED® Gold certification.

To enable the collaborative, open atmosphere required for the Livermore Valley Open Campus (LVOC) initiative, while also providing a secure environment for executing Sandia business, a new environment for trusted computing was implemented. A thorough cyber risk assessment provided the basis for an innovative network and desktop configuration relying on a virtual private network, desktop encryption and other means to **ensure a secure, high-performance, reliable computing environment.** (8300, 8900) IMS

In an effort to further protect against the loss of personally identifiable information (PII), **Sandia implemented a Data Loss Prevention (DLP) tool to protect unclassified, sensitive data from unauthorized use and transmission.** The DLP tool continually scans outbound email and internet traffic, as well as data stored on enterprise-managed file systems such as SharePoint and the dropzone, to automatically take remediation action to prevent PII from being exposed to unauthorized viewing. (9300, 9500) All SMUs

Approved cyber security Risk Management Framework (RMF) supports Sandia's shift from a compliance-oriented model for cyber security to a risk-based model for managing the protection of Sandia's information and information systems. **Sandia's cyber program will now be able to use a core set of standards with appropriate tailoring based on Sandia's risks to meet requirements** identified in NNSA Policy Letters 14.1-C, NNSA Baseline Cyber Security Program, and 14.2-C, NNSA Certification and Accreditation Process for Information Systems. (9300) All SMUs

The Information Systems and Services Center and Business Management Operations Center partnered with mission organizations to develop an innovative, integrated, three-point, multiscenario cost-estimating approach tailored to meet the requirements set by NNSA for the B61 LEP Weapons Design Cost Report (WDCR). **This resulted in an accurate and well-documented estimate for the B61 WDCR,** a tailorable estimating capability to capture large programs, a model to support the W88 WDCR team, and useful input for a new Sandia cost-estimating tool. (9500, 10600) NW

Judy Spomer (9515) received the Lockheed Martin Nova award for leading a multidisciplinary, multiorganizational team to improve the enterprise search capability. The team applied advanced analysis algorithms developed by Sandia researchers to enhance the ranking of Sandia search results by merging search engine scores with probabilistically derived scores based on aggregate user actions. On the most common queries, the most appropriate link is now returned as the first link 80 percent of the time. **The time a user spends looking for the right link has decreased by 30 percent.** (9500, 5600, 1400) IMS

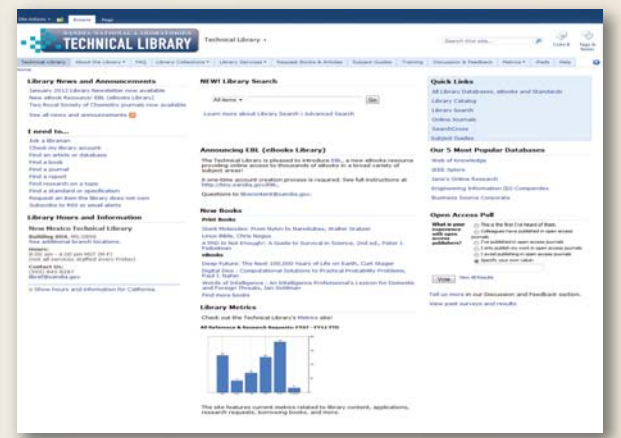
Sandia implemented version two of the Product Realization Integrated Digital Enterprise (PRIDE) portal stockpile management tool. This version supports the PRIDE target architecture, enabling an enterprise-integrated information viewing environment that ensures cross-site secure access. PRIDE portal version two enhances an integrated viewing environment using enterprise-wide and diverse authoritative sources of data. **It reduces response time for review and approval of production activity through views of information in weapon-system context using a consistent taxonomy, and it applies PRIDE target architecture as a foundation for delivering enhanced capabilities and features.** (9500) NW

International Business Operations fielded electronic travel and international hand carry (IHF) forms that expedite documentation and approval for international travel. The forms were well-received by the Laptops on Foreign Travel (LOFT) program and the Global Security Program. **The automation efforts increase efficiency by saving time and conserving resources.** The new IHF system leverages SharePoint's industry standard collaboration software to eliminate inefficiencies in the old, paper-based method of requesting and receiving approvals. SW Engineering Dept. 9543 will leverage this knowledge in other ongoing automation efforts throughout the Laboratories. (4030) IMS

An aerial view of the National Solar Thermal Test Facility.

Facilities teamed with National Solar Thermal Test Facility (NSTTF) management to implement various projects supporting the NSTTF mission. Projects funded by the American Recovery and Reinvestment Act (ARRA) included the Molten Salt Test Loop and Rotating Platform Redesign. Consistent with ARRA goals, **these projects created many jobs for local contractors to revitalize critical energy infrastructure and testing capabilities.** Facilities also constructed a fiber-optic backbone between Tech Area 5 and sites in the Coyote Test Field, significantly upgrading NSTTF mission-related computing capabilities. (4800, 6100) ECIS

The Sandia/New Mexico Technical Library deployed a set of "Library of the Future" technologies and services that provide enterprise customers with a technology-enabled environment to advance research and information management. Through enabling technologies and services, the library delivered more than 893,000 requests for information, **providing Sandia with an information content cost savings of $42 million, with a sustained 94 percent efficiency gain in information delivery.** The library also improved services through the deployment of embedded librarians and the creation of just-in-time training videos. (9500) IMS



The redesigned, enhanced Tech Library internal website for the "Library of the Future."

Computer & information sciences

Sandia partnered with Los Alamos National Laboratory and Cray to design and deploy Cielo, a 1.37 petaflop capability computing platform. **Cielo became the signature platform for the NNSA Advanced Simulation and Computing (ASC) program, demonstrating a 10 times improvement in overall capability relative to its predecessor,** LLNL's Purple platform. Cielo is currently the largest NNSA capability supercomputer available for nuclear weapons calculations and will run the largest and most demanding workloads in support of DOE's stockpile stewardship mission. (1400) NW

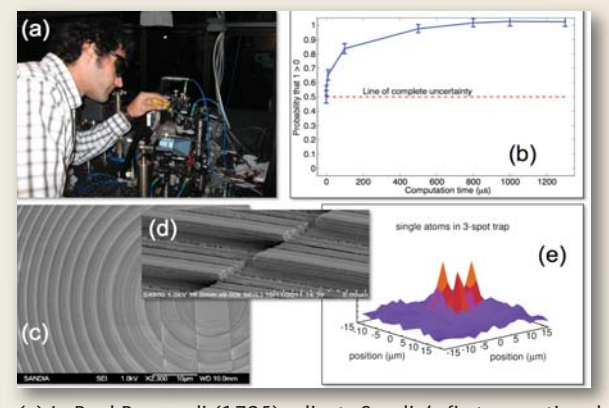
The ultimate design goal for Cielo is increased capability to achieve higher degrees of fidelity in modeling and reduce the total time to solutions.

Sandia researchers released a virtual machine introspection software library called LibVMI. This software provides foundational capabilities that enable solutions to many important applications such as increasing the security of cloud computing environments, performing run-time debugging and analysis of malicious software, and forensic analysis of compromised computers. LibVMI works by providing an external view into the memory of software running inside virtual machines or memory snapshots. LibVMI is freely available as an open source project at http://vmitools.sandia.gov. (5600) DS&A

Experimental cluster for running hundreds of thousands of lightweight virtual machines.

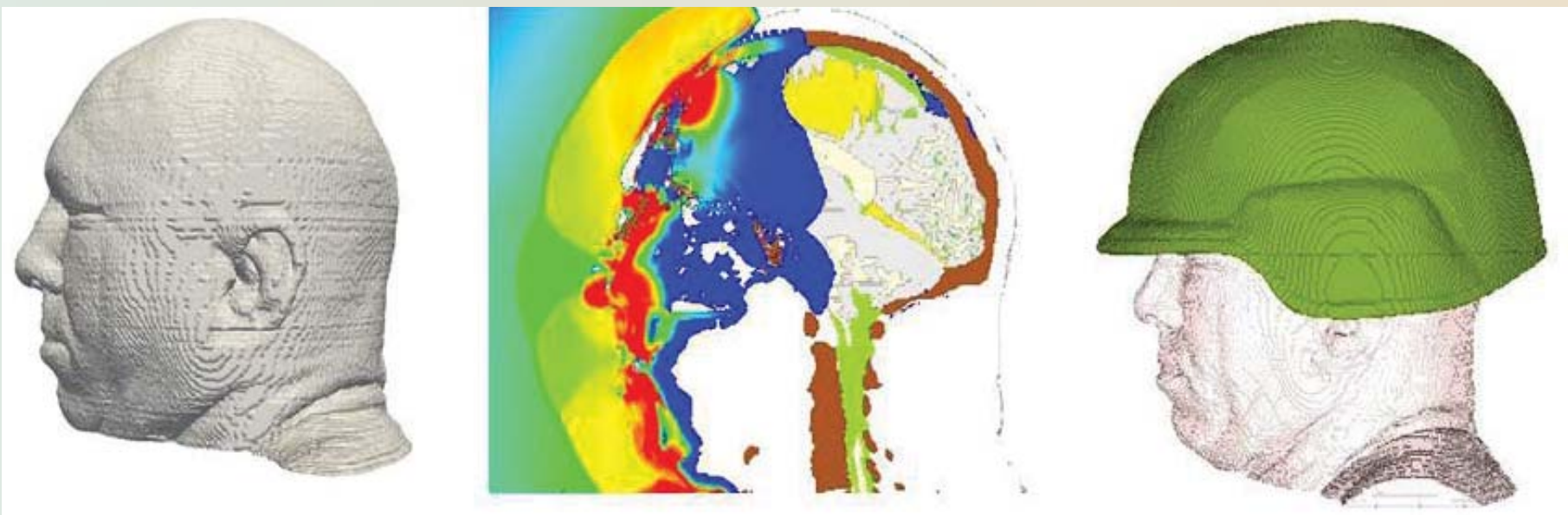
Researchers developed a 500-node testbed on which 600,000 virtual machines (VMs) such as Linux and Android can be launched, or 100,000 Windows 7 or Windows XP virtual machines. The VMs are networked together and can represent either the nodes on a network (including routers and switches) or the nodes on a supercomputer. **This testbed allows for exploration of the reliability properties of large networks, and enables the development of management tools and operating systems for future exascale computers.** The team also ran 10 million virtual machines on Jaguar. (8900) DS&A

The Adiabatic Quantum Architectures In Ultracold Systems (AQUARIUS) Grand Challenge LDRD team successfully ran Sandia's first quantum computation. The one-qubit machine built by the team processes a cesium atom laser cooled below 100 microkelvin. By "adiabatically" staying in its lowest-energy state, the device resists noise intrinsically. Its inaugural test-run calculation determined with high probability that 1 is greater than 0. While simple, a 50-qubit computer could outperform all the world's supercomputers for some problems. Sandia's unique fabrication facilities enable key AQUARIUS technologies, including nanoscale diffractive optics for atom trapping and control. (1100, 1400, 1700, 5600, 8900, 9300) CTO, DS&A, IHNS, NW



(a) L. Paul Parazzoli (1725) adjusts Sandia's first operational (one-qubit) quantum processor. (b) Its first quantum calculation. (c & d) Sandia diffractive optical element for a second-generation two-atom trap. (e) Trapping signals from a third-generation Sandia three-atom trap. Future AQUARIUS devices will use these next-generation traps.

Military programs



Digital head/neck model | Exposed to frontal blast | Marine Lightweight Helmet

Members of Integrated Military Systems Center 5400 are investigating, in collaboration with the University of New Mexico Health Sciences Center, blast-induced traumatic brain injury (TBI) and its mitigation by means of protective headgear by conducting high performance computational studies. This work studies the relationship between impulsive loading and the intracranial stresses and wave energies experienced by the brain during blast exposure. Threshold values of intracranial stress and wave energy are identified that necessarily lead to TBI and are used as metrics to assess the protective merit of various helmets. (5400) DS&A

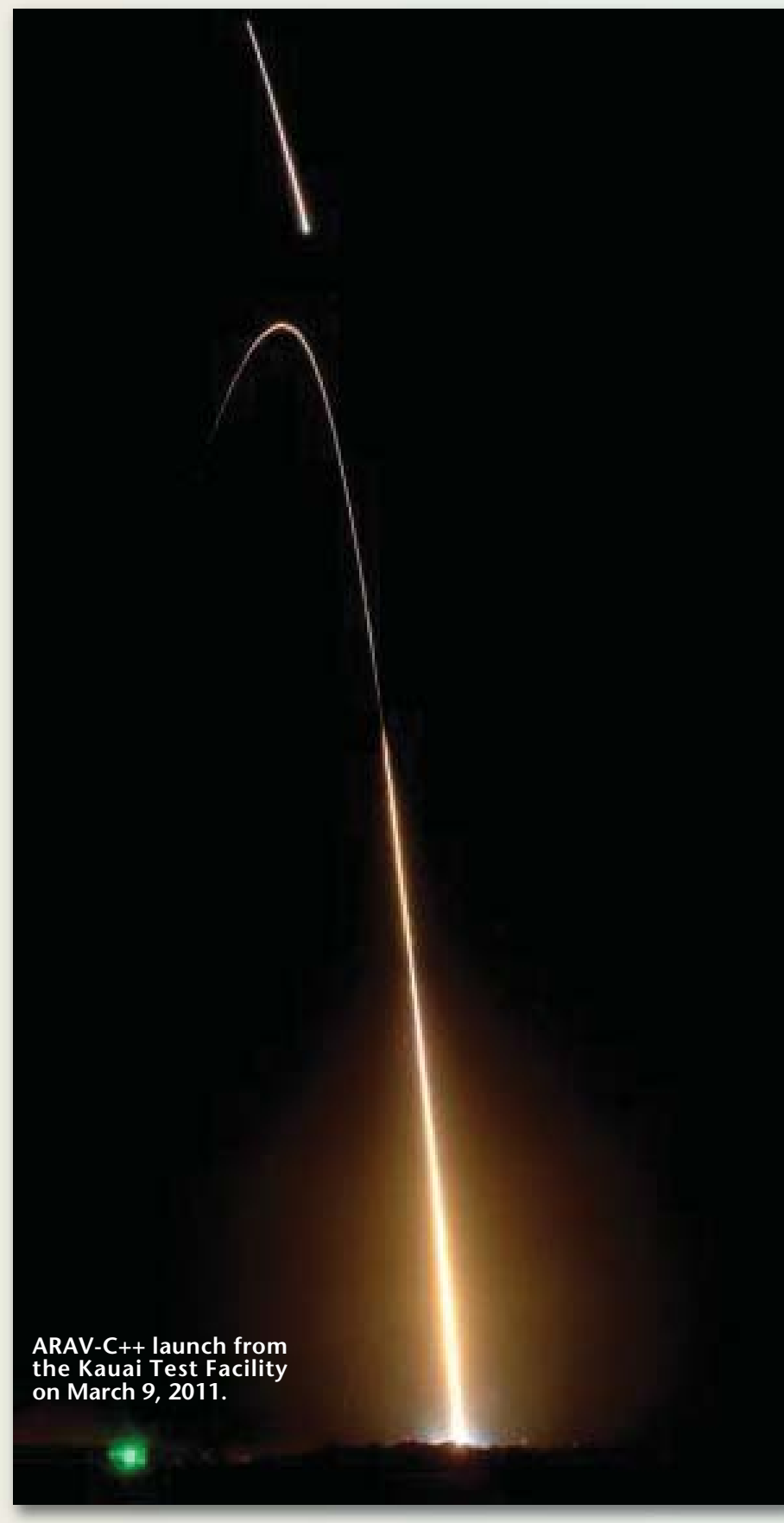
Sandia's Integrated Military Systems Program supported the Aegis Ballistic Missile Defense program on March 9, 2011, with a successful ARAV-C++ launch from the Kauai Test Facility (KTF). During the mission, Sandia provided launch support and produced the missile's attitude control module (ACM) containing all electrical, navigation, and communication systems along with a complex hydrazine propulsion system. On March 15, KTF provided range and field support for a successful launch-to-impact ballistic missile tracking test of the Missile Defense Agency's Space Tracking and Surveillance System (STSS), testing whether two low Earth-orbiting satellites could track a missile through all phases of flight. (5400) DS&A

Two Vibration Multiplexers (VMux) successfully flew on the Navy Demonstration and Shakedown Operations (DASO-22) flight in March 2011. Each VMux contains eight vibration channel inputs sampled with Sigma-Delta analog-to-digital converters, which provide near-Nyquist sampling. **The telemetered data contains twice the vibration sensor bandwidth as compared to previous flights using the same sample rate.** This high quality data is being used to evaluate the Alternate Release Assembly's (ARA) effects on environments. (2662, 2115, 1527) NW

Sandia has successfully transitioned a DARPA research and development program for a microscale ultrahigh-speed chemical warfare agent detection system with multi-dimensional processing to a DoD field-deployable sensor program funded by DTRA. **This sensor technology has demonstrated the lowest false alarm rate for any hand-held detection system and is being implemented for military field operations in support of US tactical forces.** This work is being performed at Sandia in the MESA facility and in collaboration with the University of North Carolina and Caltech. (1700) DS&A

Sandia researchers performed vehicle attitude estimation by incorporating a phase-locked loop into an extended Kalman filter for a flight test system with limited instrumentation. **This analysis was then coupled with a visualization framework to animate body dynamics, allowing rapid communication of system performance.** (2662, 2112, 2952) NW

Vehicle attitude visualization.



ARAV-C++ launch from the Kauai Test Facility on March 9, 2011.

Homeland security

DISASTER RELIEF — Chuck John and Steve Mier (both 8116) use the SUMMIT iPad app to visualize calculated building damage during an NLE-11 exercise conducted in Jonesboro, Ark. (Photo by Steffan Schulz)

Sandia piloted the Standard Unified Modeling, Mapping and Integration Toolkit (SUMMIT) software architecture at the Federal Emergency Management Agency (FEMA) National Level Exercise (NLE) 2011. SUMMIT is a software architecture that federates data, modeling, and simulation tools to create unified, quantitatively measurable scenarios for enhanced national preparedness exercises. The NLE 2011 pilot deployment culminates work with the DHS Science and Technology Directorate (DHS S&T) in response to Presidential Policy Directive 8 on National Preparedness. SUMMIT is in transition from DHS S&T to FEMA after the strong positive reception during its pilot usage. (8100, 8900, 6900) IHNS

Sandia was a key participant in a $10 million multi-agency project, the Bio-Response Operational Test and Evaluation (BOTE) project. This project consisted of three indoor biological agent release tests to evaluate the efficacy of three different decontamination methods. **Sandia was responsible for much of the data acquisition, data management, and data analysis on the project using the Building Restoration Operations Optimization Model (BROOM) system.** Sandia also trained EPA personnel to use the BROOM system during an operational exercise. (6600, 8100) IHNS

This series of images depicts a scenario in which first responders gather and analyze data with the Building Restoration Operations Optimization Model (BROOM) system in a facility as part of a decontamination effort.

Product realization

Calibration of pulsed neutron detectors is a unique PSL capability.

Sandia, in collaboration with LANL and LLNL, provided NNSA headquarters with five deliverables, identifying strategies to enhance the nation's ability to hedge against technical failures and geopolitical changes and planning options for phased stockpile development and production to support the October Nuclear Weapons Council meeting. The concepts and options developed reflected the interdependencies of stockpile size and age, requirements, force structure, design and production capabilities, and workloads; critical nuances inherent to technology maturation, weapon architecture, commonality and adaptability; and relative costs and scope. (200, 2100, 6100, 6600, 8200) NW

In FY11, **the Primary Standards Laboratory (PSL) completed about 940 calibrations of reference and transfer standards for the Nuclear Security Enterprise** (NSE) Contractor Standards Labs (CSL). These standards are used by the CSLs to perform more than 75,000 calibrations annually in support of nuclear weapons product realization. In addition, the PSL successfully renewed its ISO/IEC 17025 accreditation from the National Voluntary Laboratory Accreditation Program (NVLAP), managed by the National Institute of Standards and Technology (NIST). Renewal required an in-depth technical evaluation of PSL procedures, technical competency, and quality management system. (2500) NW

Designers in the Computer Aided Design group are meeting the challenge of managing the B61 Life Extension Program (B61 LEP) mechanical design definition by using Sandia Product Data Management (SPDM) tools on both the Sandia Restricted and Classified Networks. **The use of Product Data Management "Share" Projects allows data exchange between systems level and component designers while upholding need-to-know requirements.** The design team has extended the use of the same tools to allow secure exchange of data in "real time" with LANL designers. (2900) NW

Supply chain

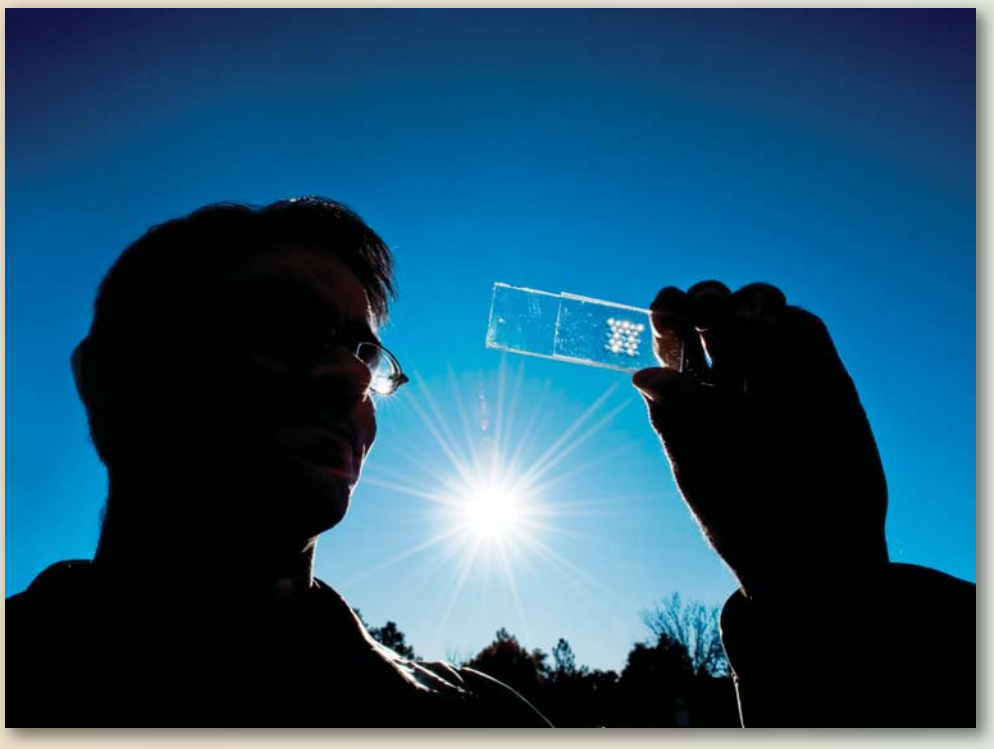
For the third time in four years, **Sandia's Fleet Services was named by *Government Fleet* magazine as one of the "100 Best Fleets in the Country."** Sandia's standing rose from 77th to 27th in 2011. More than 38,000 municipal, county, state, and federal fleets are eligible for the award. The award recognizes and rewards peak performing fleet operations by challenging them to examine their strengths and weaknesses and prompts them to measure and evaluate their practices in relation to the principles of good fleet management. (10200) IMS

Victor Cano-Linson of Sandia's Fleet Services fills up a government vehicle with E85, a green fuel composed of 85 percent ethanol and 15 percent gasoline. (Photo by Randy Montoya)

Sandia's Fleet Copier Program has been instrumental in encouraging members of the workforce to use secure networked copiers instead of individual desktop printers for their copying, printing, and scanning needs. **The program received a silver award in the 2011 Federal Electronics Challenge.** The award recognizes Sandia's purchase of greener electronics, reduced impacts of electronics during use, and management of used electronics in an environmentally safe way. (9300) All SMUs

Partnerships & alliances

Lockheed Martin Corporation (LMC) Relations worked closely with LMC to provide Sandia with best business practices, including those to accrue significant cost savings and to avoid unnecessary costs. **This strengthened the Labs' technology partnership with LMC**, which included licensure of Sandia's decision-support software, Technology Review and Assessment Model (TRAM), to assist in making better informed technology decisions. (0010, 6100) NW, DS&A



Sandia received three technology transfer awards from the Federal Laboratory Consortium (FLC): the Gemini-Scout Mine Rescue Robot, providing a tool for first responders to mining accidents; Microsystems-Enabled Photovoltaic cells, a revolutionary way to collect solar power; and an intellectual property partnership with the University of New Mexico, enabling improved technology commercialization with UNM. The FLC recognized Sandia's continuing impact on the US public good through these technology transfer partnerships. (0100, 1900) ST&E, ECIS

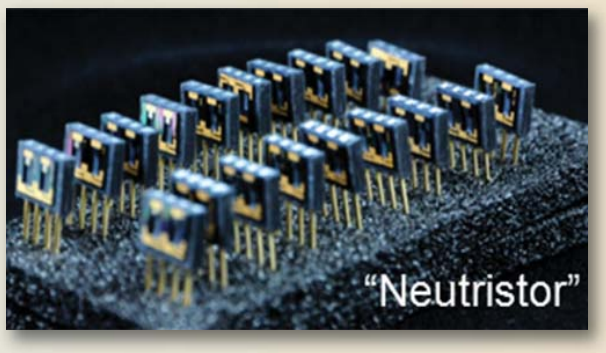
Sandia researcher Greg Nielson, team leader on the Microsystems-Enabled Photovoltaic cell project, holds up a sample of the cells that won a regional Excellence in Technology Transfer Award from the Federal Laboratory Consortium. (Photo by Randy Montoya)

Microelectronics & microsystems

The next generation of mobile computing devices will require advanced radio frequency (RF) filter and oscillator banks covering multiple frequency bands. These microsystems will perform RF filtering and frequency synthesis functions in next-generation wireless handsets, cell phones, and other wireless devices, offering higher performance and frequency diversity in a smaller package and at a lower price than current technologies. "Our miniature acoustic resonators fill this need," says Roy Olsson (1719), the primary investigator on the R&D 100 Award-winning project. **Rockwell Collins Inc. has partnered with Sandia to achieve the next-generation of microresonator filters and frequency references.** (5200) DS&A

Sandia has demonstrated the highest frequency micromechanical filters, operating in excess of 10 GHz. The filters use Sandia's R&D100 Award-winning aluminum nitride microresonator technology to shrink the filter size to 0.5 x 1.0 x 0.2 mm^3, including bond pads. This is orders of magnitude smaller than the electromagnetic filters typically used in these frequency bands. **The high operating frequency, extremely small size and low insertion loss make these filters ideal for application in X-band radio frequency systems,** such as radars and satellite communications. (1700, 5300) DS&A, NW

Neutron generators, the last holdout of vacuum tube technology, are entering the new millennium; the neutristor is what the transistor is to old vacuum tube technology, revolutionizing traditional thinking. **A new configuration for neutron generators is emerging that may enable a transition from conventional cylindrical tubes to the flat geometry of computer chips.** The technical challenge uses a one-dimensional slice through the common vacuum tube and still produces neutrons using the concept of a linear particle accelerator. (1700, 1800, 2600, 2700) NW



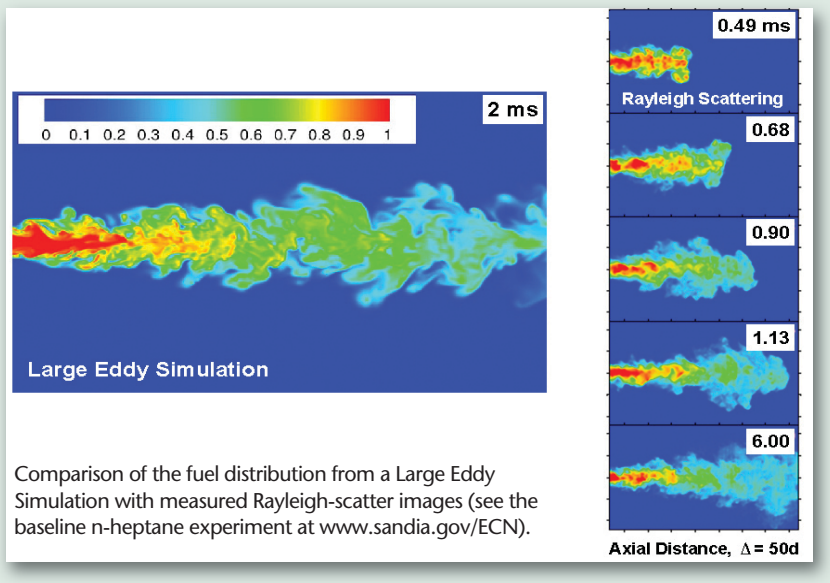
The neutristor revolutionizes neutron generator science.

Engineering sciences

Sandia has made the SIERRA mechanics engineering code suite available externally through two dissemination routes. The software is now available as a binary distribution, making possible 30-minute desktop or HPC installations with minimal assistance. In contrast, the full code format required days for installation. Much of SIERRA mechanics has also been made available to a broad user community through the Trilinos code distribution. Making SIERRA more widely available is key to further improving our capabilities and enabling wider impact, internally and externally, in advancing engineering sciences. (1500) NW

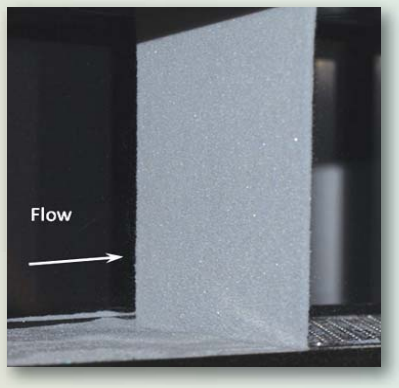
The Independent Review Team for the Aerial Cable Facility issued its final report in May. Using information from site surveys, technical reports, interviews, observations of test demonstrations, and analysis of specific hazard scenarios, the team evaluated the technical basis for operations, focusing on electrical hazards and controls associated with explosives operations. Then, applying the principles of assured safety and engineered safety, as articulated by Div. 1000 VP Steve Rottler in March 2010, **the team made several recommendations to improve safety that were implemented by the staff at the Aerial Cable Facility.** (0400, 2100, 2800, 2900, 6600) NW

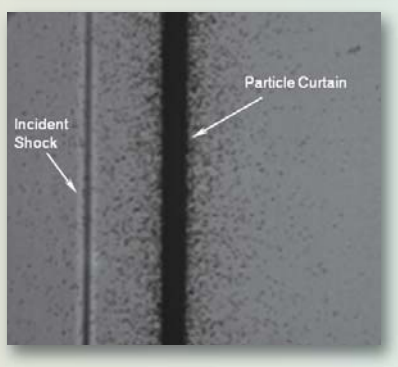
Accurate prediction of fuel injection processes is recognized as a critical need for the development of advanced internal combustion engines. **Researchers at the Combustion Research Facility have performed joint computational and experimental studies to account for real-fluid nonideal behavior that exists when conditions are supercritical, a situation applicable to modern engines.** A series of high-fidelity large-eddy simulations was performed, considering engine sprays at supercritical conditions for the first time. The simulations are able to reproduce key experimental features of flow structure and mixing. (8300) ECIS



Comparison of the fuel distribution from a Large Eddy Simulation with measured Rayleigh-scatter images (see the baseline n-heptane experiment at www.sandia.gov/ECN).

A unique multiphase shock tube, developed through an LDRD project, is providing physical insights into shock-particle interactions within a dense gas-solid flow that occurs early in energetic material detonation. Little understanding of particle dynamics exists for this regime and such knowledge is needed for predictive models to address the explosive dispersal of a lethal particulate. **Sandia is now providing complementary, scientifically controlled data for use in the CTH code and to increase the understanding of multiphase blast physics of interest to the broad defense community.** (1515, 1512) DS&A, NW





The left photograph shows the multiphase shock tube that uses a dense particle curtain (right top) impacted by a shock wave (right bottom) to produce shock-particle interactions.

HR & finance

Health, Benefits, and Employee Services introduced a healthy lifestyle incentive program using Virgin HealthMiles' activity and risk-based system to complement Sandia Total Health, the consumer-driven healthcare plan promoting wellness and prevention. Employees enrolled in Sandia Total Health can earn an additional $250 toward their deductible by practicing healthy behaviors and participating in on-site wellness activities. With partner Extend Health® administering retiree health care enrollment, **Sandia reduced cost by $3 million and increased the number of retiree health plan choices.** (3300) IMS

In FY11, Sandia experienced higher-than-normal numbers of retirements and new hires. **The total members of the workforce remained relatively stable through workforce acquisition planning, by which Sandia hired 1,130 regular employees, while 427 employees retired.** The new hires are of top quality and represent educational, gender, and ethnic diversity. Sandia continues to emphasize attracting and recruiting high-quality candidates from the nation's top engineering schools. To achieve these results and support the future, Human Resources continues to make processes lean, emphasizing simplicity, alignment, efficiency, and effectiveness. (3500) All SMUs

Sandia's Payroll staff improved the timekeeping application to clearly reflect the Fair Labor Standards Act workweek for all nonexempt employees and to allow all employees to enter their own project and task descriptions. Other improvements include removal of start/out/in/stop times and Friday midday to Friday midday (for nonexempts) beginning/end of workweek; time reporting codes represented as a TRC; project/task description option for employee ease of determining projects worked on during the week; certification of time worked; and Sandia/California meal and break certification. (10500) All SMUs

In response to Sandia's mission customer's request, the CFO changed the way travel costs are burdened, starting in FY12. **The change aligns Sandia's load structure with industry practices and more accurately captures the actual costs associated with purchasing and managing a trip.** The Controller's Center communicated the change to Mission Support divisions and worked with the CIO and IT Services to quickly update the forward pricing rates and the many corporate and line organization tools. (10500) IMS

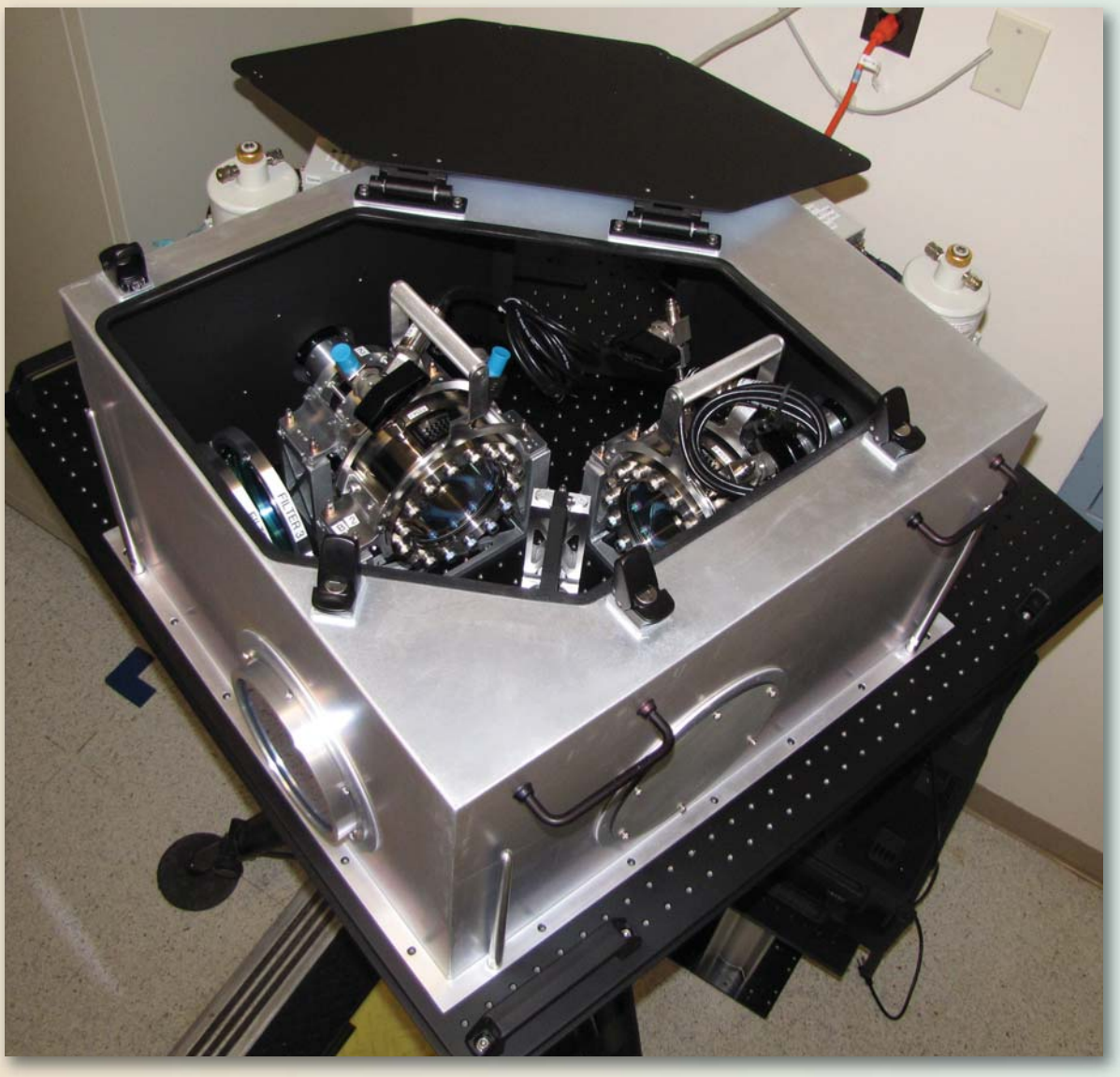
Sandia completed a major R12 upgrade to its Oracle E-Business computer applications. The 20-month project involved administrative and technical staff from multiple divisions. Sandia was one of the first in the DOE enterprise to upgrade, which is instrumental to supporting the complex's IT upgrade strategy. Despite the significant changes, the upgrade was transparent to the Labs' line organizations. The new features include an accounting engine called subledger accounting, a payment module, and a consolidated buyer's workbench. **These features will create efficient business processes to support the Labs' mission.** (2700, 9500, 10200, 10500) All SMUs

Contract Audit developed and implemented a mentoring program that seven of their new hires completed in FY11. This successful program has been requested and is being adopted by other organizations throughout Sandia, as well as other laboratories. Consistent with the Labs' strategic objective to provide a learning, inclusive, engaging environment, particularly at a time when Sandia is experiencing a large influx of new employees, **this program ensures new hires the most advantageous start to succeed and contributes to their development as future leaders.** (800) All SMUs

Global security

The Project Neptune team completed the design, fabrication, and integration of a unique R&D sensor focused on detection of chemicals indicative of nuclear proliferation. The Neptune sensor will be able to remotely interrogate regions of interest to determine if nuclear proliferation signatures are present. **A multi-center team completed the sensor on schedule and under budget.** In the spring of 2012 the team will participate in proliferation-detection field tests at the Nevada National Security Site. (5700, 2600, 2900) DS&A

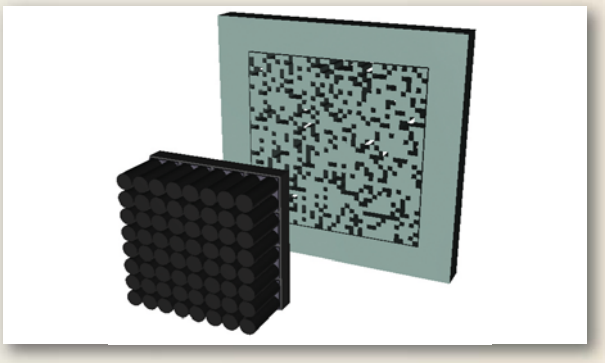
The Neptune sensor has been developed to support nuclear proliferation detection missions.



Sandia leads a multi-agency team to develop and operate the Gulf Nuclear Energy Infrastructure Institute (GNEII), a capability designed to develop a responsible nuclear energy culture in future decision-makers of Middle East regional nuclear energy programs. **Ten young Emirati nuclear professionals completed the rigorous GNEII Fundamentals pilot course** and are now ready to apply their comprehensive nuclear energy safeguards, security, and safety-related analytical capabilities to their jobs. GNEII continues to receive high regards from the US, the UAE, the IAEA, and other relevant entities. (6800) IHNS

Building on our long-standing role of developing and maintaining the US radiation detection equipment (RDE) that was used for on-site inspections in Russia for the Intermediate-Range Nuclear Forces (INF) Treaty and the original START treaty, **Sandia performed tests, calculations, and evaluations of the US RDE for the New START Treaty,** which took effect Feb. 5, 2011. Sandia also played a key role in a US interagency assessment of the Russian RDE to be used during New START Treaty inspections in the US. (6800, 5900, 6600) IHNS

High-resolution imaging of special nuclear material is important in applications such as arms control treaty verification. One fast neutron-imaging technology, pursued in collaboration with Oak Ridge National Laboratory, is coded-aperture imaging, which processes the pattern cast by a shadow mask to create an image of the neutron source distribution, such as nuclear warheads in a missile silo. By optimizing the pattern of the coding masks, **researchers are able to reduce noise in the image and achieve better sensitivity to anomalous distributions of neutron emitters.** (8100) DS&A



Rendering of a coded-aperture neutron imager with a so-called random mask. The mask was optimized for imaging in busy environments, such as those encountered in arms control treaty verification applications.

Infrastructure protection

In early February 2011, New Mexico experienced the coldest weather on record since 1951. Temperatures ranged from a low of -8 degrees F in Albuquerque to -36 degrees F in Angel Fire, resulting in a loss of natural gas to portions of the state, including Sandia. **The Labs' Emergency Operations Center and Facilities personnel proactively responded to prevent significant freeze and flooding damage to Sandia facilities.** As a result, little to no effect on missions was experienced from burst pipes when compared to many other statewide industrial and military installations. (4800, 4100, 4200, 10600, 10200, 1700) IMS

The first snowfall of the season roared into Albuquerque in early December 2011, riding on the back of near-hurricane force winds and arctic temperatures. Sandia called for a two-hour delayed start on Monday, Dec. 5; with deteriorating conditions, employees who had been able to report for work that day were released early. By Tuesday morning, most employees were able to return to work as usual. Above, Robert Naranjo (4848) braves the cold to clear snow from the walk in front of Bldg. 811 on Monday, Dec. 5. (Photo by Randy Montoya)

A patent for a flexible, leave-in-place eddy current sensor to allow structural health monitoring (SHM) without the need to have a person and an instrument present to do an inspection was awarded to several present and past members of the Infrastructure Assurance and NDI Department. Eddy currents can detect cracking and corrosion in electrically conductive materials. **This is one of many SHM advancements pioneered at Sandia.** The work was done under an LDRD project. (6600) ECIS

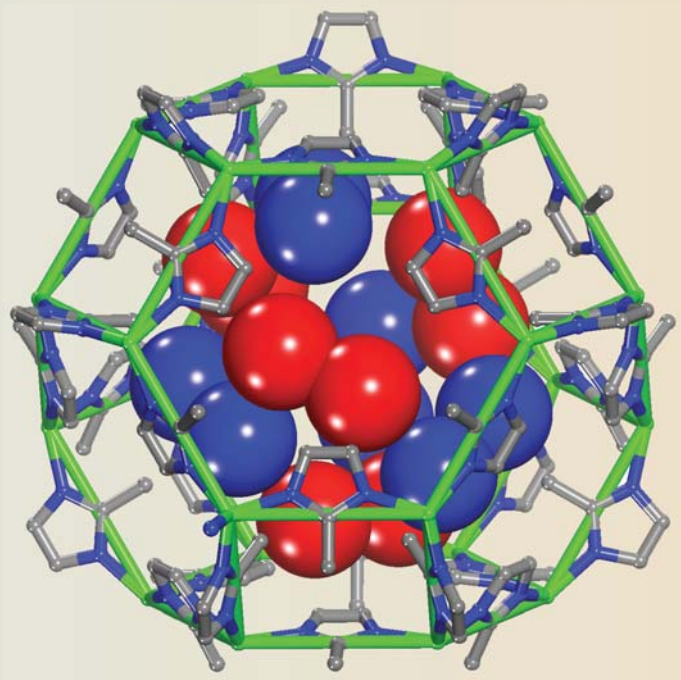
An in-situ eddy current sensor, which has been patented by Sandia National Laboratories.

Sandia, EnerNex, the Tennessee Valley Authority, and Schweitzer Engineering Laboratories, partnering in the Lemnos security project, **successfully demonstrated a Sandia-developed architecture and prototype implementation of a cyber security interoperability framework for communications** at the Electric Power Research Institute (EPRI). The DOE Office of Electricity Delivery and Energy Reliability has highly praised and presented the Lemnos Project and the resultant product capabilities as a major success in addressing some of the challenges described in the DOE Roadmap to Secure Control Systems in the Energy Sector. (5600) ECIS

Sandia completed a multiyear development project for the Department of Homeland Security's Science and Technology (S&T) Directorate that focuses on modeling and analyzing the supply chains of the nation's chemical sector. Capabilities of the project transitioned from the S&T Directorate to the National Infrastructure Simulation and Analysis Center (NISAC) on Sept. 1, 2011, **providing NISAC and its customers in the DHS Office of Infrastructure Protection with better details on effects to the chemicals sector resulting from hurricanes, earthquakes, and other natural disasters.** (6900, 6100) IHNS

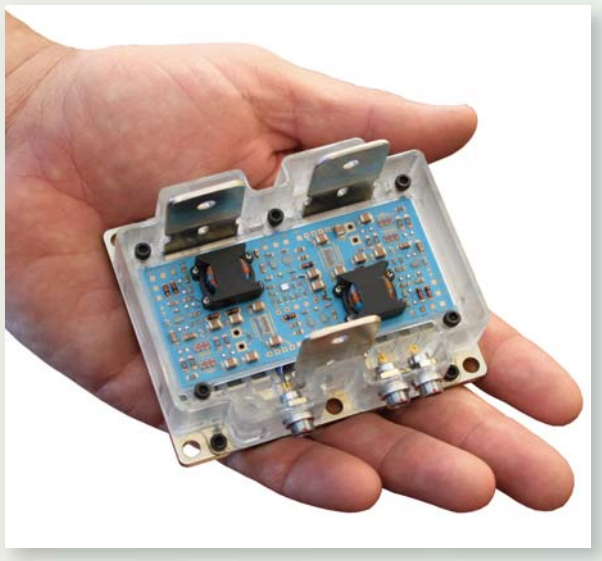
Energy

Sandia researchers provided critical expertise in support of immediate and future DOE Nuclear Energy Wasteform Materials needs. In response to the Fukushima emergency, they provided key insight vital for adapting available crystalline silicotitanate materials for addressing radioactive cesium ion capture needs. Also, innovative metal-organic frameworks (MOFs) are being investigated and show superior characteristics useful for radiological fission capture from nuclear fuel reprocessing and/or nuclear accident scenarios. Sandia researchers collaborated on publications about MOFs for radiological iodine capture that were recently highlighted by the Royal Society of Chemistry. The incorporation of these MOFs materials into a glass waste form was published in a special issue on nuclear energy in the journal *Chemical Engineering and Industrial Research*. (1100, 1400, 1800, 6900) ECIS



A ball-and-stick representation of the beta-cage in zeolitic imidazolate framework-8 (ZIF-8) MOF. Hydrogen and oxygen atoms in the structure were omitted for clarity; Zn= green, C= gray, N= blue. The porous cage in ZIF-8 highlights two independent I_2 binding sites (the large red and blue spheres); up to 6 I_2 molecules can be trapped inside the cage, equivalent to 110 percent molecular iodine adsorbed by weight.

In a project sponsored by DOE's Energy Storage Program and managed by Sandia, in partnership with GeneSiC Semiconductor Inc. and the US Army Armament Research, Development and Engineering Center, Sandia has developed an ultra-high-voltage silicon carbide thyristor. **The semiconductor device allows next-generation "smart grid" power electronics systems to be built up to 10 times smaller and lighter than current silicon-based technologies.** These packaged-power devices are the world's first commercially available, high-voltage, high-frequency, high-current, high-temperature, single-chip SiC-based thyristors. (6100) ECIS



Ultra high voltage silicon-carbide-thyristor

Sandia received a prestigious DOE EStar award for exemplary environmental sustainability in water conservation. Water-efficiency projects at Bldg. 858 J CUB, 858 North, 899A CUB, and other areas reduced water consumption by 30 percent, which equates to a savings of more than 200 million gallons of water annually from a 2007 baseline. Water is supplied to the New Mexico site from the Albuquerque aquifer, a precious resource to our community. (4800) ECIS, IMS

Ionic liquids formed with transition metal cations (MetILs) provide a pathway to lower cost, higher energy storage flow batteries. Here, Chemical Technologist Harry Pratt (2546) synthesizes a copper-based ionic liquid.
(Photo by Randy Montoya)

Sandia completed a successful deployment of a new mobile laboratory for measurements of greenhouse gases and tracers of greenhouse gas sources. The project was part of a larger tri-lab BER/NNSA-funded project. The mobile laboratory was deployed for the first time for six weeks at the DOE Atmospheric and Radiation Measurement (ARM) Southern Great Plains (SGP) site in Oklahoma to measure the stable isotopes of CO_2 and species co-emitted with CO_2. (8100, 8300, 6900) ECIS

Sandia, LLNL, and LANL team members take in the view from the roof of the Atmospheric and Terrestrial Mobile Lab.

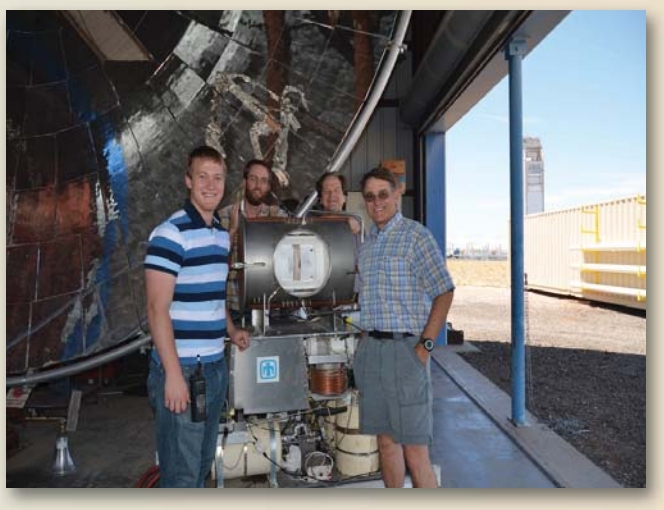
A new family of metal ionic liquids (MetILs) synthesized by researchers in the Power Sources Technology Group has the potential to triple the energy density of flow batteries used for grid-scale energy storage. The liquid phase exhibited at room temperature is due to formation of asymmetric cations that prevent ion pairing. Since MetILs act as electrolyte and solvent, a higher concentration of active material is achieved compared to conventional flow battery electrolytes. The work was featured on the November cover of *Dalton Transactions*. (2500, 6100) ECIS

Since being established in January 2010, **the Blue Ribbon Commission (BRC) on America's Nuclear Future has requested several staff and management from the Nuclear Energy and Fuel Cycle Programs (Center 6200) to play a key role** in informing the BRC in its deliberations through briefings and white papers, including the science supporting the Waste Isolation Pilot Plant's compliance certification application, the regulatory framework for high-level waste disposal, an overview of DOE Office of Nuclear Energy's storage and transportation program, and three briefings on 9/11 vulnerability assessments. (6200) ECIS

Sandia researchers have demonstrated a multijunction solar cell, combining crystalline silicon, gallium arsenide and indium gallium phosphide junctions — which are normally incompatible — using 3-D integration techniques. This allows a new class of microsystem-based multijunction photovoltaic (PV) cells that does not have the handicaps of lattice matching and current matching that limit traditional multijunction III-V solar cells. Researchers have also demonstrated new microsystem approaches that allow for high-efficiency flexible PV material. **This breakthrough should allow approximately a four-fold improvement in conversion efficiency compared to currently available flexible PV.** (1700) ECIS, DS&A

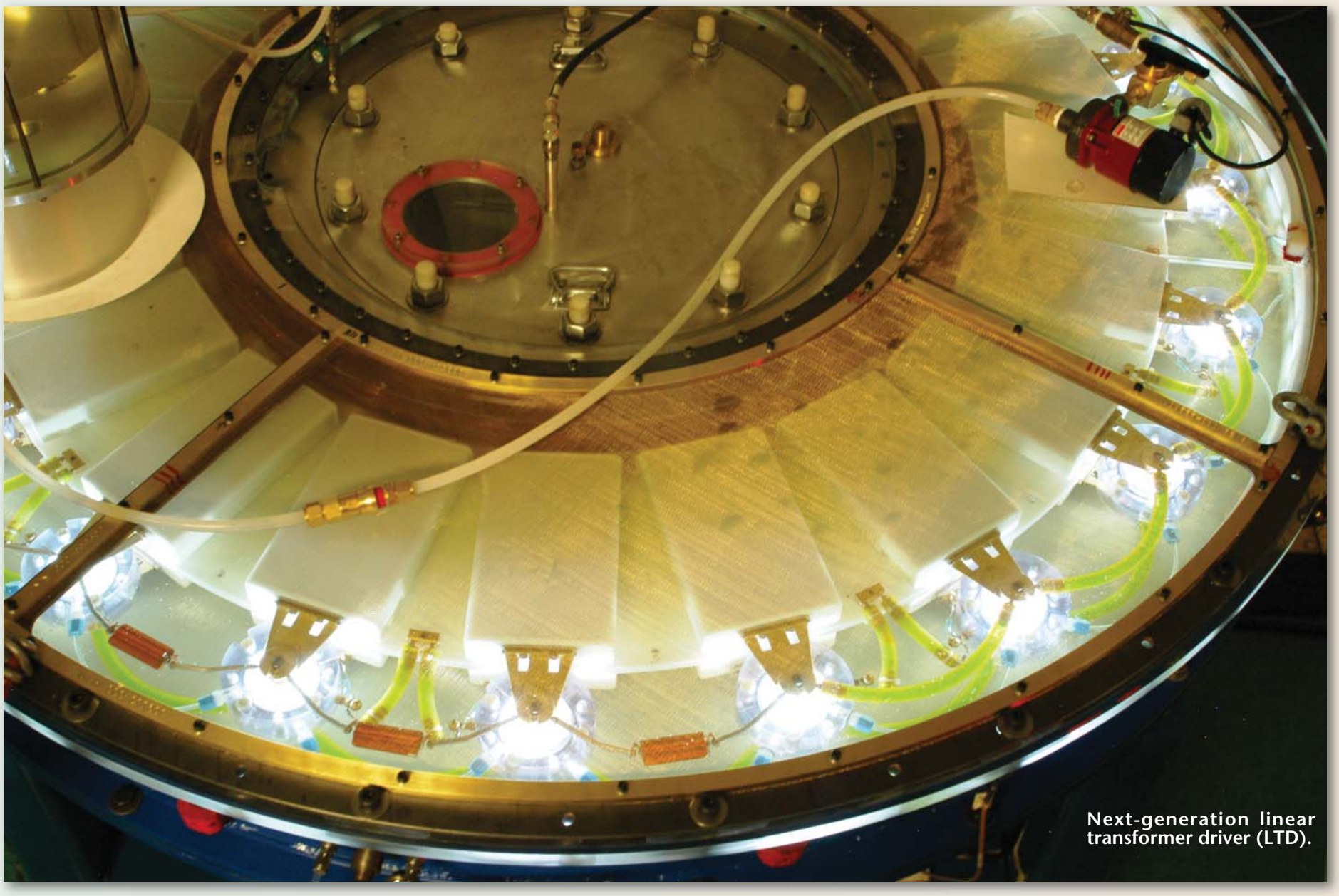
A Sandia-university team proved the feasibility of splitting carbon dioxide using high-temperature solar energy with a device that combines heat exchange, thermochemistry, and gas flow all in a single package. The "Sunshine to Petrol" team tested the "Counter-Rotating Ring Receiver Reactor Recuperator" in August 2011 at the National Solar Thermal Test Facility in Albuquerque. Making CO from what might otherwise be a waste stream (CO_2) with solar energy is the first step in making synthetic gasoline and diesel fuel. The team is motivated to reuse CO_2, store solar energy in liquid hydrocarbon bonds, and create domestic transportation fuels.

A carbon dioxide splitting experiment under test at the solar furnace.



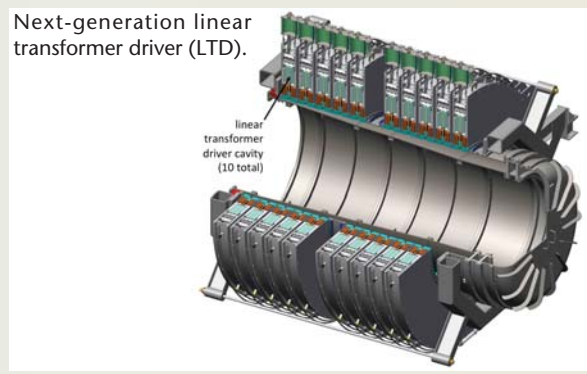
Several members of staff with the Counter-Rotating Ring Receiver Reactor Recuperator.

Pulsed power



Next-generation linear transformer driver (LTD).

Linear transformer drivers (LTDs) are twice as efficient as the technology used since the 1960s in pulsed power accelerators such as Z. **Sandia researchers have doubled the peak electrical power generated by an LTD without increasing its dimensions or number of components.** Sandia has selected this technology for a proposed next-generation accelerator that will deliver an order of magnitude more electrical power than Z. The new machine will allow experiments in material physics, inertial confinement fusion, radiation effects, and laboratory astrophysics at previously inaccessible parameter regimes. (1600) NW



Next-generation linear transformer driver (LTD).

The heavy noble gases are colorless and electrically insulating as liquids or solids, but their properties transform dramatically with increasing pressure and temperature. By shock compressing these materials in Z Machine and performing computer simulations based on quantum mechanics, **researchers have determined the thermophysical properties of argon, krypton, and xenon with remarkable precision up to unprecedented pressures of almost 10 million atmospheres** (10 Mbars). This focused, accelerated effort has established a new foundation to understand the behavior of these intriguing elements under extreme conditions. (1600, 1400) NW

Neptune and Uranus are largely composed of water as are, undoubtedly, many of the 500 exoplanets in other star systems. In partnership with the University of Rostock in Germany, **Sandia researchers have determined the properties of these "waterworlds" at planetary conditions.** High-accuracy experiments on Sandia's Z Machine to compress water to 7 million atmospheres (7 Mbars) and computer simulations based on quantum mechanics enable an improved understanding of planetary evolution and a plausible explanation for the anomalous magnetic fields surrounding Neptune and Uranus. (1600) ST&E

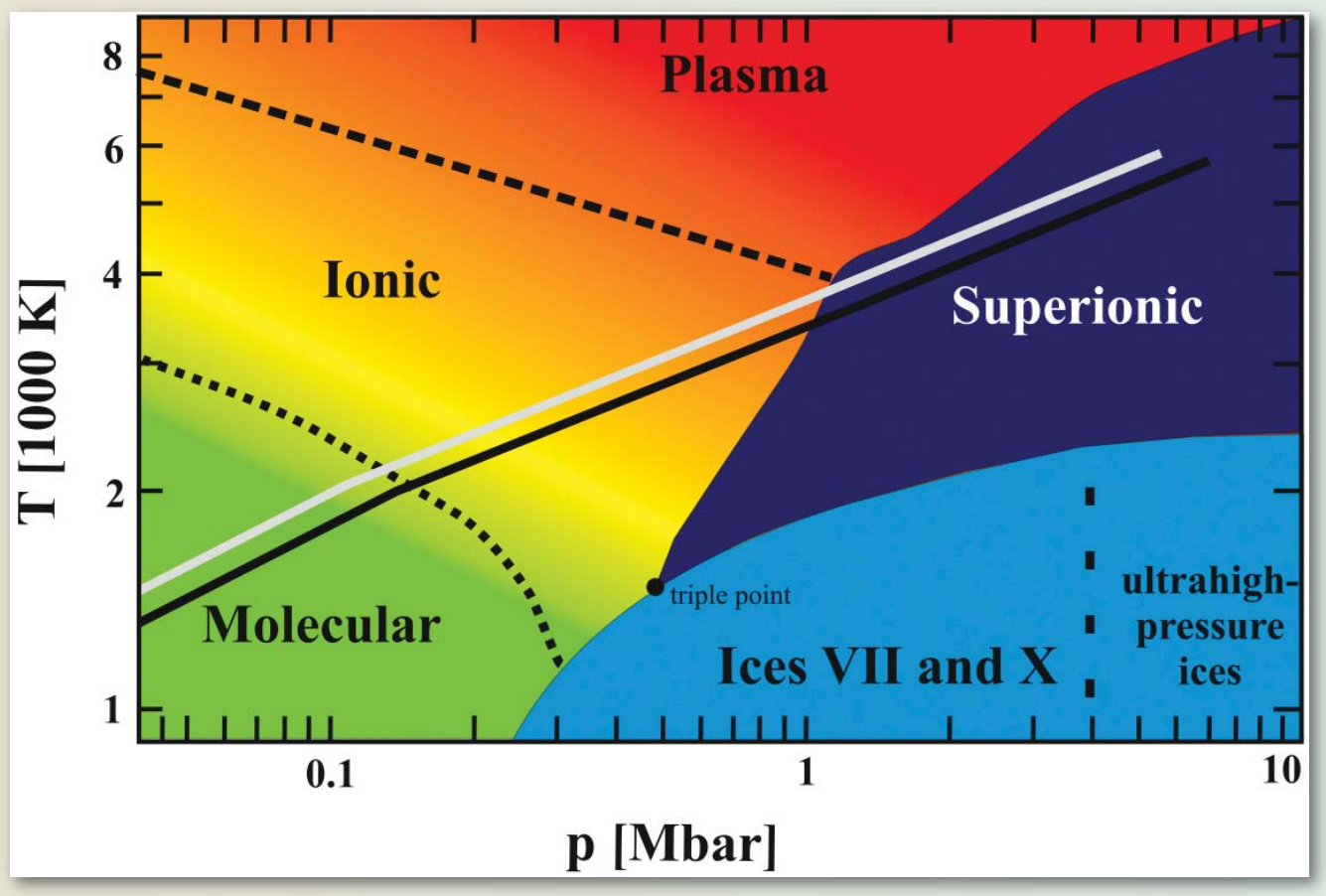


Figure from January 2011 cover of *Icarus*, showing the calculated isentropes for Neptune (thick black line) and Uranus (thick gray line) overlaid on the phase diagram of water.

ES&H & security

Sandia Security Police Officers Joseph (Joey) Branch, Norman Baca, and Ruben Padilla (4233) won the DOE three-man team event at the 39th annual DOE Security Protection Officer Competition (SPOTC). The three-day event was held at NNSA's Pantex facility in Amarillo, Texas. **This is the first time a Sandia team has won this competition.** Sandia competed against teams from DOE Headquarters, URENCO (an international nuclear fuel company), United States Enrichment Corporation PGDP, and the Kansas City Plant. (4200) IMS

Sandia's three-man pistol team, left to right, Norman Baca, Joey Branch, and Ruben Padilla (all 4233), took first place in DOE's annual Security Protection Officer Competition held at NNSA's Pantex facility in Amarillo, Texas. (Photo by Randy Montoya)

August marked the successful release of the Access Control Enabling System (ACES) badging application. Personnel Security uses ACES for granting physical site access by generating badges based on clearance status. ACES development was a cohesive effort between Personnel Security and Division 9000. The new badging application consolidates several applications to streamline the physical access process. Engineered controls for visitor clearance verification reduce the potential for security incidents by ensuring proper clearance levels. **Implementation resulted in operational efficiencies and annual cost savings of $550,000.** (4200, 9500, 8500) IMS

Following the Emcore tragedy in 2010, **Safeguards and Security, along with Corporate Investigations, assessed Sandia's capabilities for responding to workplace violence or active shooter incidents.** The assessment covered prevention, preparedness, response, and recovery. As a result, emergency response drills were developed; communications with employees were improved; training was conducted for employees and Protective Force personnel; policies and procedures were enhanced; and interagency training was conducted with Kirtland Air Force Base and external law enforcement entities on event response, coordination, and communications. (0800, 4200) All SMUs

Staff from several divisions served as members of the Home Team for Operation Tomodachi, a DOE consequence-management response to the Fukushima Daiichi nuclear-reactor failure. **Staff from Sandia's Industrial Hygiene & Radiation Protection and Critical Asset Protection & Security provided around-the-clock support for approximately six weeks**, performing duties including coordinating and managing the receipt and analysis of more than 10,000 field samples from Japan, uploading analysis results into a database, validating results for accuracy, conducting radioactive-plume and material-uptake modeling, completing radiation dose assessments, and providing measurement equipment for individuals from Sandia going to Japan. (4100, 6600, 10600, 2900) IMS

Sandia provided support to DOE/NNSA and Nuclear Energy, the Department of State, US military, and Japanese officials by supporting operations at the Consequence Management Home Team (dose assessment, dose reconstruction, laboratory analyses, 24-hour operations, etc.), **deploying to Japan for field operations and advising the US Embassy in Tokyo on data interpretation, accident progression, evacuation zones, and reactor design and functionality.** Work continues to reconstruct the accident and improve US emergency planning and response. (6200) IMS

The Infrastructure Operations Division (4000) collaborated with line operations to ensure safe and secure mission delivery for the Transuranic (TRU) Removal project. DOE asked Sandia to accept transuranic waste from Lovelace Respiratory Research Institute. Complex hazards had to be addressed to repackage and transport the waste to the Waste Isolation Pilot Plant (WIPP). This included the request of a Hazard Category 3 exemption and modifications to the Radioactive and Mixed Waste Facility. The exemption was approved, repackaging was completed safely, and the containers were shipped. (4100, 4800, 3300) IMS

The Auxiliary Hot Cell Facility began its operational journey with the successful completion of the remote-handled (RH) transuranic (TRU) waste repackaging project. The TRU waste was originally packaged in 30 casks or drums that contained highly contaminated items with significant dose-rates. Primary tasks included visual examination to document each waste item repackaged, removal of prohibited items, and radiological sampling. Additional tasks included dose-to-curie measurements and headspace gas sampling. The RH TRU waste is on track to be shipped directly to WIPP in early FY12. (1300) IMS.

Shielded by the thick walls of the Auxiliary Hot Cell Facility, David Siddoway (1387) uses the manipulators to hold a ratchet, which he will use to open the material drums. (Photo by Randy Montoya)

Transuranic waste leaves Sandia on a truck via the Eubank contractor gate. This picture shows the secure TRUPACT-II container, into which the metal drums holding the transuranic waste are placed. (Photo by Randy Montoya)

Community involvement, customer relations, institutional development

Sandia's annual Employee Caring Program (ECP) campaign raised an astounding $4.6 million to support our community through the United Way. In a year of economic uncertainty, employees increased their donations by 10 percent, many new employees joined the Labs' giving culture, and retirees contributed more than $500,000. Lockheed Martin provided a Corporate Cornerstone donation of $100,000. Sandians also serve on panels that help allocate the Community Fund dollars. (3600, entire workforce) All SMUs

Make a Difference Day 2011 — Some 250 Sandia employees, contractors, retirees, family members, and friends volunteered to help complete projects throughout the community during Make a Difference Day. In the photo, Sandia volunteers repaint the US map on the Sandia Base Elementary School playground.
(Photo by Patty Zamora)

Governance, leadership, & management

The CFO's Business Leadership Program, begun in 2011, offered Sandia's business community leaders a core set of leadership fundamentals to guide their thoughts, words, and actions as leaders. The 10-day program provides managers with a greater awareness of the business community's mission and strategic goals; a deeper understanding of the mission of the Labs' strategic management units; an expanded network of relationships within and beyond the business community; and the opportunity to contribute toward a culture of continuous leadership learning. (10600) IMS

This past year, Sandia's work for others process was impacted by legislation, DoD regulations, and DoD/DOE Inspectors General reviews. These changes were clarified in a memorandum of agreement and master interagency agreement between DoD/DOE/NNSA. **A CFO & Business Operations team assessed the impact, recommended actions to NNSA, and then implemented, communicated, and trained the employees affected by the changes with minimal impact on the SMUs.** (10010, 10500, 10600) All SMUs

Mission Support — consisting of Divisions 3000, 4000, 9000, 10000, and 11000; and orgs. 10, 30, 40, 700, and 800 — was restructured to better position the Labs to protect against risk and to address the increasing importance of information technologies. The restructure included escalating the CIO to a VP position and renaming Division 9000 as CIO & IT Services to give it greater authority; the creation of Center 700 Mission Support and Corporate Governance to better address assurance; and the creation of a Chief Privacy Officer and Corporate Risk Officer to help mitigate risk. (EVP Mission Support 00003) IMS

Corporate Governance developed an "Assurance Maturity Model" and conducted a comprehensive assessment of Sandia's assurance system (policies, processes, and procedures) and its implementation across all 25 management entities (programs, divisions, and policy areas). This baseline established a valuable reference against which Sandia measures its assurance progress, consistent with the strategic objective to lead the complex as a model 21st-century government-owned, contractor-operated national laboratory. **President and Labs Director Paul Hommert used the assessment to help determine Sandia's readiness for the NNSA Contractor Assurance System Affirmation Review, completed in November.** (700) All SMUs

Ethics & business conduct

Diversity & Inclusion bolstered its diversity tools over the past year to provide focused Labs-wide awareness at all levels through a variety of venues. The monthly Diversity Cinema Program included new diversity-related videos that offered employees an opportunity to engage in meaningful, face-to-face dialogue. The organization created an online library that offers practical tools for employees to build their skills or lead diversity discussions. The library includes a list of books, videos, and other tools available to be checked out. Complete details are available at http://diversity.sandia.gov/. (0040) All SMUs

The Diversity and Inclusion website, http://diversity.sandia.gov/.

A key player in a new NNSA-funded consortium, Peter Marleau (8132) says lead academic partner UC-Berkeley will take advantage of Sandia's work in neutron imaging systems for nonproliferation, including the neutron scatter camera seen here.
(Photo by Dino Vournas)

A key player in a new NNSA-funded consortium, Peter Marleau (8132) says lead academic partner UC-Berkeley will take advantage of Sandia's work in neutron imaging systems for nonproliferation, including the neutron scatter camera, seen here.
(Photo by Dino Vournas)

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