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SANDIA TECHNOLOGY

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VOLUME 8, NO.4

Expanding access to microfluidic fittings

Riddle of the desert glass

Understanding 'metallic water'

Sandia National Laboratories

What is LDRD

Sandia's world-class science, technology, and engineering work defines the Labs' value to the nation. These capabilities must remain on the cutting edge, because the security of the U.S. depends directly upon them. Sandia's Laboratory Directed Research and Development (LDRD) Program provides the flexibility to invest in long-term, high-risk, and potentially high-payoff research and development that stretches the Labs' science and technology capabilities.

LDRD supports Sandia's four primary strategic business objectives: nuclear weapons; energy resources and nonproliferation; defense systems and assessments; and homeland security and defense. LDRD also promotes creative and innovative research and development by funding projects that are discretionary, short term, and often high risk, attracting exceptional research talent from across many disciplines.

When the LDRD logo appears in this issue, it indicates that at some state in the history of the technology or program, LDRD funding played a critical role.

On the Cover:

Ron Renzi of Sandia's Advanced Concepts and Micro-systems Engineering department examines a microfluidic multiport selector valve. Story begins on page 2.
(Photo by Jeff Shaw)

Sandia Technology (ISSN: 1547-5190) is a quarterly magazine published by Sandia National Laboratories. Sandia is a multiprogram engineering and science laboratory operated by Sandia Corporation, a Lockheed Martin company, for the Department of Energy. With main facilities in Albuquerque, New Mexico, and Livermore, California, Sandia has broad-based research and development responsibilities for nuclear weapons, arms control, energy, the environment, economic competitiveness, and other areas of importance to the needs of the nation. The Laboratories' principal mission is to support national defense policies by ensuring that the nuclear weapon stockpile meets the highest standards of safety, reliability, security, use control, and military performance. For more information on Sandia, see our website at *www.sandia.gov*

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FROM THE *Editor*

Dear Readers,

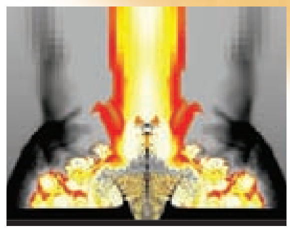
Whether it's sniffing baseball fans at an Oakland A's game for chemicals of interest, protecting oil and gas infrastructure, understanding the physics of water in extremely high temperature and pressure regimes, or searching for the explanation of the origins of the mysterious Libyan Desert Glass, Sandia researchers are at it again.

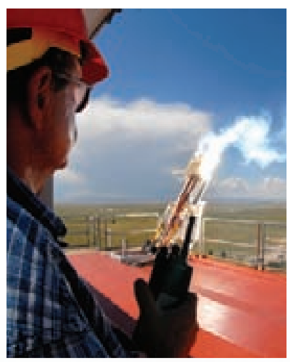
This issue highlights the scope of our work. We're extending technology to one of America's leading agribusiness corporations to help develop seeds that will grow crops that can be more readily converted to energy. We're working with NASA on a new idea for the satellites of tomorrow. We're illuminating the workings of solid-state lighting at a new national center. And we've dedicated an important new facility to help the Department of Homeland Security better prepare for terrorist attacks or natural disasters.

Finally, a request that you give us the benefit of your opinion, please! Attached to this issue (or at the online address listed on the form) is a brief survey. We'd love to get your name and address information up to date, added, or deleted, as appropriate. More importantly, we'd love to hear your ideas about our publication's relevance to your own work. We promise to read and consider it all!

Will Keener
Editor

TABLE OF *Contents*





Expanding researcher access to microfluidic fittings

Story by Nancy Garcia

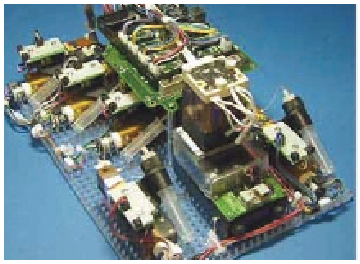
Necessity was the mother of invention for a recently licensed suite of microfluidic fittings, manifolds, and interconnects that allows researchers and engineers to configure their own analytical devices and potentially form integrated systems for myriad applications. The suite . . . has become much used in the last three or four years.

Inventor Ron Renzi in his lab with an integrated biotoxin analysis system with an automated sample preparation front end. (Photo by Jeff Shaw)

LDRD

The valves have been tested for more than 1.2 million cycles, demonstrating a robustness that enables creation of reliable autonomous systems in the field.

— Yolanda Fintschenko
manager, Microfluidics Department



Closer look at Sandia's biotoxin analysis and sampling system.

"It's the only time at Sandia I've seen anything propagate like this," says inventor Ron Renzi, a Sandia microsystems engineering researcher. "It's amazing how well-received these technologies have been." The tool set he's referring to, a kind of micro-plumbing set, was developed by a Sandia team, simply because nothing else was available.

The suite was developed during the initial stages of a MicroChemLab Laboratory Directed Research and Development LDRD Grand Challenge program, Renzi says, when he could not find commercially available components to easily form fluidic seals in small spaces. MicroChemLab was designed to enhance traditional wet-bench chemical analysis of such threats as trace explosives and biotoxins by rapidly and portably separating samples on chips under an applied voltage.

With the help of Art Pontau, senior manager of the Materials and Energy Sciences group, and Jim Wilhelm, who handled the licensing agreement, the fittings were licensed late last year to LabSmith, a Livermore, California-based hardware company formed by former Sandia researchers Eric Cummings and Kirsten Pace.

Working on the initial MicroChemLab project eight years ago with Mark Claudnic and Tom Raber, the team developed the first component, called CapTite — a one-piece ferruled fitting with thread connections for sealing to thin, flexible capillaries. This solved the problem of getting fluids to microchannels on chips in a way that prevents troublesome leaks or bubbles.

The next year, manifolds and interfaces that provide consistent fluid connections with simple and accurate alignment were developed.

Microthruster development

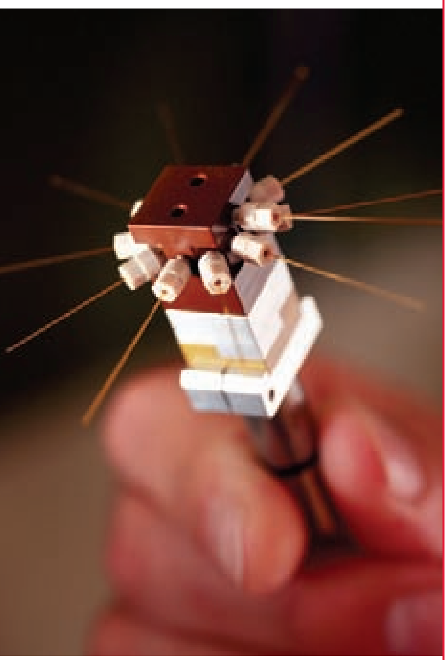
One example of an application is the LDRD-funded microthruster development, where designs are being explored for using propellants in nanosatellites. These small satellites can be used for communications, surveillance, or networking. The fittings allow different configurations to be tested, so that mixing an oxidizer to increase thrust can be investigated. Liquid propellants are moved using electrokinetic pumping, in which an electric field causes flow of a liquid in a packed bed. The flow reaches the closed end of a capillary and drives a reverse, pressure-driven flow that can be tailored to the application by altering the size of particles in the packed bed.

Several patents have been issued or applied for with the assistance of Sandia's Scott Ferko, a coinventor of the patented one-piece ferrule. Patents awarded so far include those associated with compression manifolds, microvalves, and high-pressure fittings. The fitting is capable of withstanding pressures up to 40,000 psi and can be used in smaller versions of the standard benchtop analytical tool, liquid chromatography systems requiring 10,000 psi.

The microvalves include a multiport selector valve that has been continuously improved over the last two years and is now frequently and reliably employed in microflow and nanoflow systems.

"The valves have been tested for more than 1.2 million cycles, demonstrating a robustness that enables creation of reliable autonomous systems in the field," says Yolanda Fintschenko, manager of Sandia's Microfluidics department. The fittings are also being used to enable selective concentrators.

Sandia researchers have improved upon using this well-known force phenomenon



This multiport selector valve is one example of a Sandia-developed microfluidic component. (Photo by Jeff Shaw)

(termed dielectrophoresis) by placing insulating obstacles within microchannels, and the associated electrodes outside in reservoirs. The insulating posts, arrayed in the middle of the microchannel, constrict the electric field and create an electrical field gradient that gives rise to the particle separation. This approach is much easier to fabricate (using injection-molded polymers) than the previous glass-based approach. Some believe this technology, known as iDEP (for insulator-based dielectrophoresis), could revolutionize biological sample preparation. iDEP technology is currently the focus of a cooperative research and development agreement with Lockheed Martin Corp.

Nanotechnology applications

In New Mexico, these tools are enabling a discovery platform for mechanical testing, optical interrogation, electronic manipulation, and measurement at the Center for Integrated Nanotechnologies. Researchers envision applications in medical, defense, and similar fields.

One medical diagnostic application is a small portable device that within minutes could screen saliva for markers of periodontal disease and blood samples for early indicators of heart disease. Funded by the National Institutes of Health, this effort includes collaborators at the University of Michigan's schools of dentistry and engineering, as well as the Cornell University's applied and engineering physics program.

"The initial investment blossomed into a real success story, and a fundamental strong element of that was the engineering," Renzi says. "It's gone a long way. . . . We have great science here, and we also have great engineering to enable the science." More than 20 second-generation MicroChemLab boxes relying on these technologies are currently used in Sandia programs. The components are modular and employ a common breadboard and control architecture.

"Researchers can grab the components, draw a flow schematic, integrate and assemble the parts in hours instead of days, weeks, or months," Renzi says. "We want to take the chemist away from the problem and not be doing wet chemistry out in the field."

Renzi is also lead engineer on a team incorporating the fittings and other enabling technologies into the BioBriefcase project, an environmental monitoring collaboration with Lawrence Livermore National Laboratory. The Department of Homeland Security-sponsored project calls for a compact broad-spectrum bioagent detector that autonomously collects, prepares, and analyzes samples using three techniques in a portable unit complete with a system to archive samples for further analysis.

Another DHS-funded project using this suite of microfluidic tools is the Enhanced Bioaerosol Detection project. Besides Sandia, it includes Lawrence Livermore, Oak Ridge, Pacific Northwest, and Los Alamos national laboratories, as well as Yale University and the Army Research Laboratory. The prototype is a selective aerosol collector and fluorescence spectrometer under investigation for potential use as a low-false-alarm-rate early warning sensor.

"The technologies have propagated through different programs," Renzi says, "not all of which they were invented for." This is likely to continue as the field of microfluidics and its applications evolves.

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Homeland Security chief dedicates new center

Department of Homeland Security Secretary Michael Chertoff dedicated a new National Infrastructure Simulation and Analysis Center (NISAC) at Sandia in September.

Chertoff, members of the New Mexico congressional delegation, and other officials were briefed on NISAC's technical contributions to the nation's homeland security and saw demonstrations of several technologies.

NISAC is a partnership between Los Alamos National Laboratory and Sandia under the DHS. It was established six years ago to integrate the laboratories' expertise in modeling and simulation of complex systems to examine both natural and manmade infrastructure national security issues.

These capabilities aid decision makers in preparedness, consequence and risk analysis, policy analysis, investment and mitigation planning, education and training, and provide near-real-time assistance to crisis-response organizations.

During the 2006 hurricane season, NISAC analyzed regions vulnerable to hurricane damage so that data on key population issues, impacts of infrastructure disruptions, and economic consequences could be quickly available to impacted communities in the event of an actual emergency.

NISAC is the first facility built at a DOE site using DHS funding and illustrates the increasing importance of Sandia's nonnuclear research and development. DHS is currently working with priority projects, including radiological and nuclear countermeasures, explosives detection, chemical and biological sensors, and facility protection efforts.

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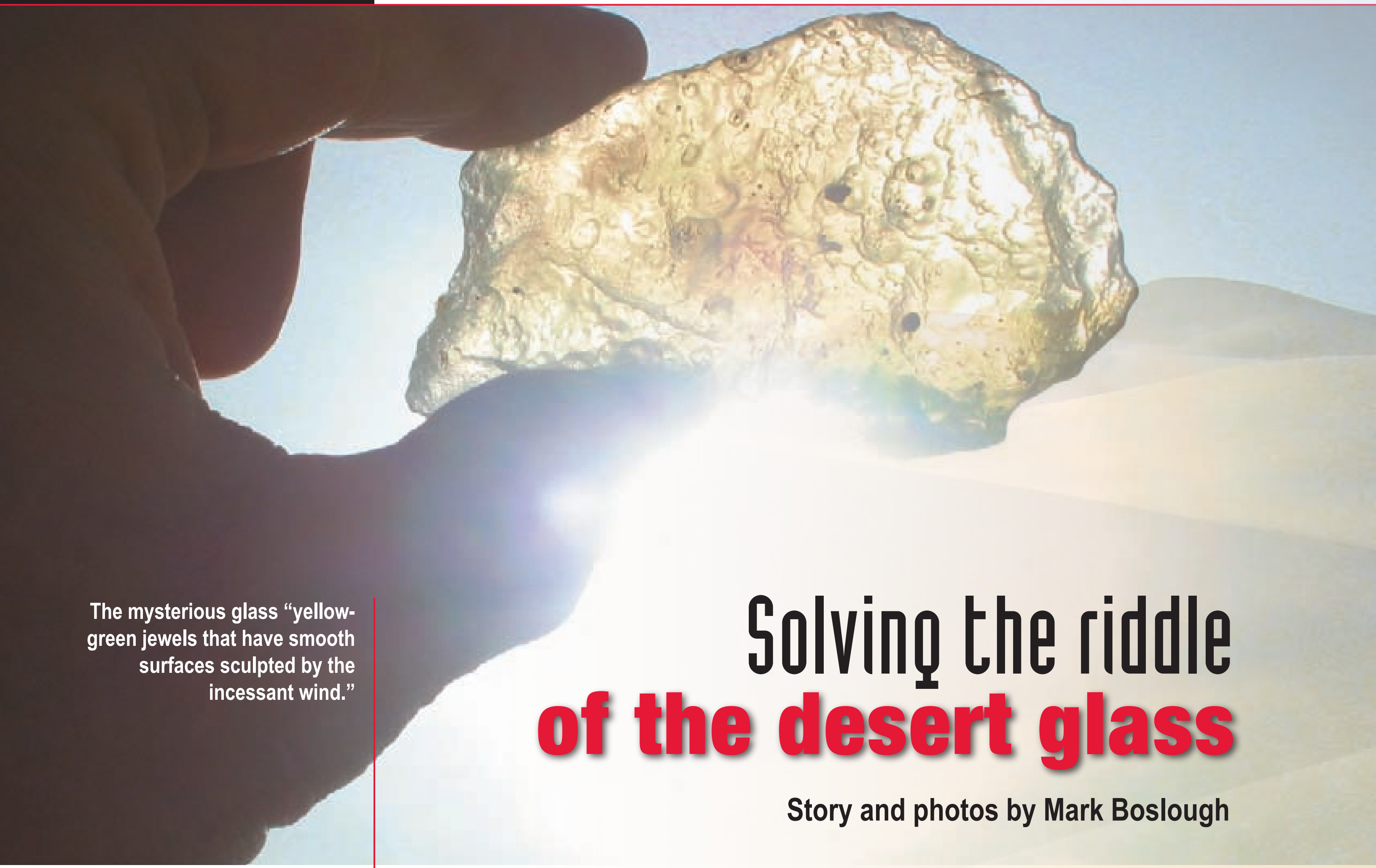
NISAC website: http://www.sandia.gov/mission/homeland/programs/critical/nisac.html

NISAC

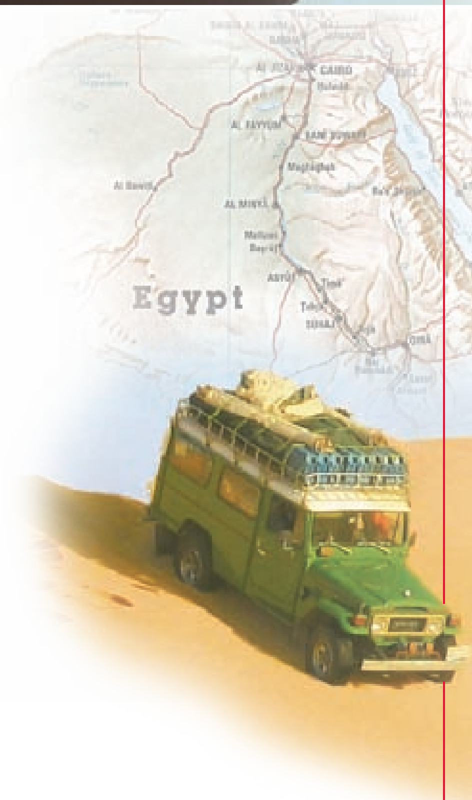
Department of Homeland Security Secretary Michael Chertoff and other officials dedicated the new National Infrastructure Simulation and Analysis Center at Sandia in September.



The mysterious glass “yellow-green jewels that have smooth surfaces sculpted by the incessant wind.”

Solving the riddle of the desert glass

Story and photos by Mark Boslough



It was in 1932 that British explorers in Model-A Fords first visited this area of western Egypt, where they discovered a mysterious yellow-green glass scattered across the surface. Ever since, Libyan Desert Glass has fascinated scientists, who have dreamed up all sorts of ideas about how it could have formed. It’s too silica-rich to be volcanic. In some ways it resembles the tektites generated by the high pressures associated with asteroid impacts. That observation is the starting point of a scientific debate that became the subject of the documentary filmed for National Geographic and BBC.

I was chosen to participate in the role of a dissenter from the preferred explanation that the glass was formed by direct shock-melting by a crater-forming asteroid impact. I had stumbled into the debate by accident in 1996, when I attended a conference on the subject of the 1908 explosion of an asteroid or comet that knocked down nearly a thousand square miles of trees in Siberia. I stayed an extra day to attend a meeting about the desert glass, where I argued that similar — but larger — atmospheric explosions could create fireballs that would be large and hot enough to fuse surface materials to glass, much like the first atomic explosion generated green glass at the Trinity site in 1945.

King Tut connection

Shortly after that workshop, one of the Italian organizers made a discovery that raised public interest in the subject. Vincenzo de Michele visited the Egyptian Museum in Cairo, and noticed that one of King Tutankhamun’s jeweled breastplates contained a carved scarab that looked suspiciously like a piece of the glass. A simple optical measurement confirmed the

Speeding across the vast expanse of Sahara desert sand in a four-wheel drive vehicle was not something Sandia's Mark Boslough had thought to put on his calendar when he planned this year's activities. He nevertheless found himself — with other scientists and a British film crew— examining an enigmatic silica glass that has survived for 29 million years.

match in 1998. The connection of a catastrophic explosion with the treasures of ancient Egypt became a sure-fire formula for a documentary.

Last December, when I was first asked by the producer to be interviewed, I was a little skeptical. After all, television is known more for sensationalism than for scientific accuracy, and the King Tut connection had fueled pseudoscientific speculation on the web. One website even presents fanciful "Evidence for Ancient Atomic War," making the case that Egyptians had detonated nuclear weapons (but ignoring the fact that the glass is 29 million years old). Did I want to be part of this?

Fortunately, I was assured by other scientists that this would be a legitimate documentary that would focus on natural explanations for this enigmatic glass. In February, I found myself in Cairo with Dr. de Michele, getting a firsthand look at King Tut's glass scarab and preparing for nine days in the desert.

Great Sand Sea

Our jumping-off point was the Bahariya Oasis, a large valley of villages and adobe houses. After the 300-kilometer drive on a two-lane highway through the lifeless desert, the irrigated fields were startlingly green — the last green we would see for some time.

Leaving the road, we embark on a 1,000-km voyage across the Great Sand Sea. Despite the lack of water, that name is apt. Like mariners, we don't follow a specified route. We are guided by the sun, compasses, dead-reckoning, and (like modern sailors) GPS. If the dunes are the swells of the open ocean, our first day's trip is an excursion though a field of icebergs. Towering monuments, hoodoos, and mesas of stark white limestone provide a maze through which we meander, opening up to a featureless flat sand plain.

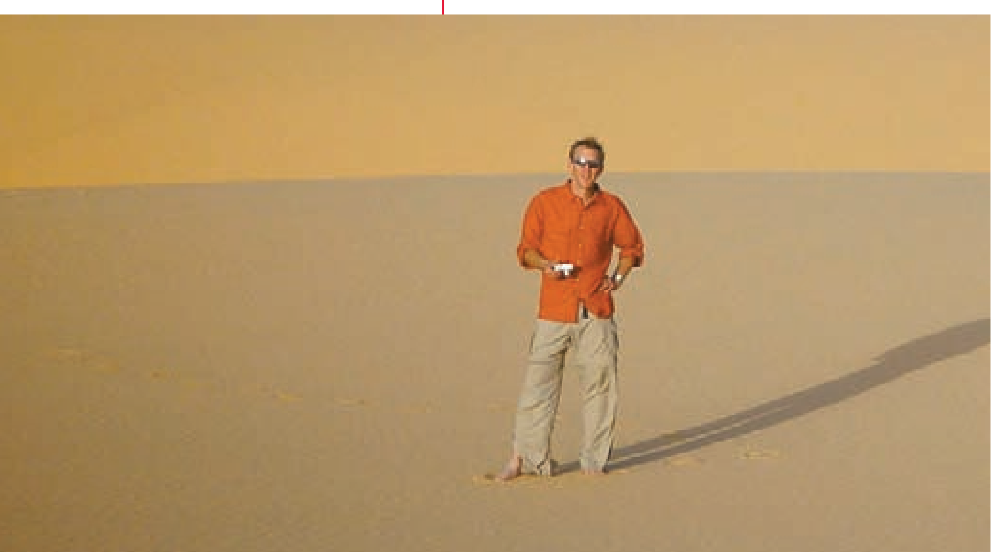
"The first bits of glass we find are yellow-green jewels that have smooth surfaces sculpted by the incessant wind. We hold them up to the sun to see how the light refracts and scatters."

Our Egyptian outfitter, his French partner, and the local drivers and crew make this trip several times every year. They plot their GPS tracks on satellite images downloaded from the web. They never repeat the same route, but offset their trips by enough distance that they explore parts of the desert that have never been crossed before.

Bedouin-style tea

February in the Sahara is cool, and the wind blows so hard on the Great Sand Sea that it can be hazy like a marine fog. Our meals here are accompanied with sugar-saturated tea brewed Bedouin-style over an open flame of apricot wood carried from the orchards of Bahariya.

To the southwest, the rolling sand builds to great dunes and the sea rises. Vehicles frequently get stuck and have to be rescued by digging and driving them up special aluminum ramps. It takes a special sailor's eye to distinguish between a safe hard surface and the treacherous soft sand, especially at 100 kilometers/hour. Arabic, French, and English conversations crackle over the radio, and throbbing Egyptian music plays on the driver's iPod.



Sandia's Mark Boslough in western Egypt. He approached the assignment with some healthy skepticism, but now believes the effort bore some scientific fruit.

Just before we reach the site of the glass, the dunes become linear — unbroken parallel ranges running north-south for hundreds of kilometers. Here we must carefully pick our crossings, and then we run at high speed southward in the corridors between the dunes, the "freeways" that have been used by nomads for centuries (as evidenced by 100-year-old camel skeletons).

On our third day after leaving the last road, our maps tell us we are within the area where glass has been found. We stop to look. There are pieces of sandstone everywhere, and no plants in sight. It looks strikingly like the surface of Mars, and sand sifts underfoot. The first bits of glass we find are yellow-green jewels that have smooth surfaces sculpted by the incessant wind. We hold them up to the sun to see how the light refracts and scatters. This is probably what the Pharaohs did with their piece, and the Neolithic people before them.

Nine days of geologic exploration and discussion bore fruit. You get to know your colleagues well during long days driving and long nights in camp. Everyone figures out the strengths and weaknesses in one another's ideas. It would be premature to claim that we solved the mystery, but new friendships and collaborations have emerged, and renewed interest in this scientific mystery has energized debate over this unique glass.

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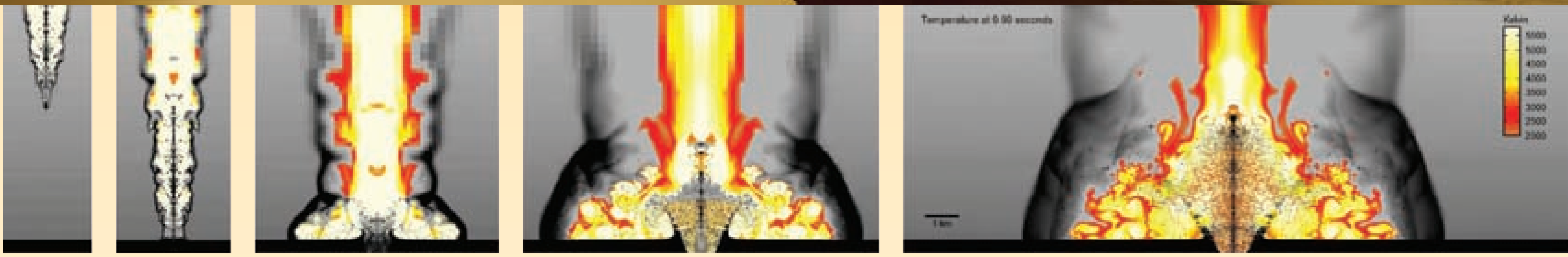
Applying high-performance computing to a scientific mystery



Red Storm simulated the airburst and impact of a 120-meter diameter stony asteroid, shown in this sequence. Meteoric vapor mixes with the atmosphere to form an opaque fireball with a temperature of thousands of degrees. The hot vapor cloud expands to a diameter of 10 km within seconds, still in contact with the surface.

How did the glass form? Boslough, working with Sandia's Red Storm computer, offered a simulation that suggests one possible solution: an asteriod airburst.

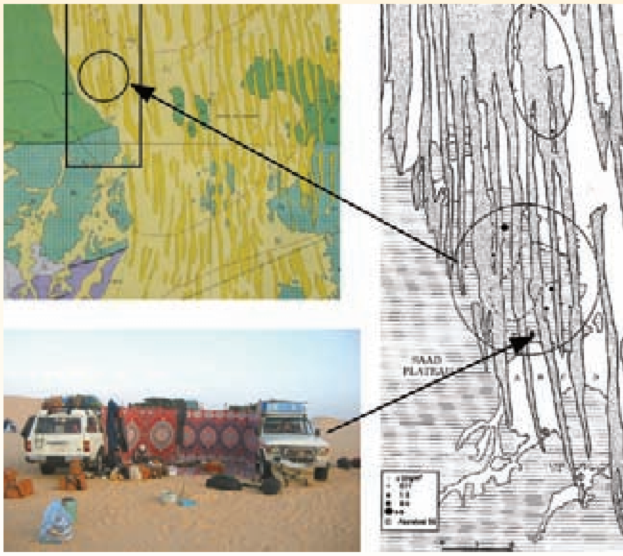
While most natural glasses are volcanic in origin, rare exceptions are tektites, formed by shock melting associated with hypervelocity impacts of comets or asteroids. The Libyan Desert Glass falls into neither of these categories and has baffled scientists since its 1932 discovery.

Sandia physicist Mark Boslough's study of the 1994 collision of Comet Shoemaker-Levy 9 with Jupiter provided an opportunity to model a hypervelocity atmospheric impact. Along with observation of the actual event, the model provided insights that provided a likely scenario for the formation of the Libyan Desert Glass.

Using Sandia's Red Storm supercomputer, Boslough and his team ran a three-dimensional simulation, using huge amounts of memory and processing power. The simulation supports the hypothesis that the glass was formed by radiative heating and ablation of sandstone and alluvium near the "ground zero" of a 100-megaton or larger explosion caused by the breakup of a comet or asteroid.

The shock-physics simulations show a 120-meter-diameter asteroid entering the atmosphere at a speed of 20 kilometers/second and breaking apart just before hitting the ground. The fireball generated by the explosion remains in contact with the Earth's surface at temperatures exceeding the melting temperature of quartz for more than 20 seconds. The fireball and the air speed behind the blast wave (hundreds of meters per second during the 20 seconds) are consistent with melting and rapid quenching to form the Libyan Desert Glass.

Although the risk to humans for such an impact is remote, it is not negligible, Boslough notes. The precise probability of such an event and its consequences are difficult to calculate, but research on large aerial bursts is forcing risk assessment to recognize and account for these large natural processes.



Expedition camp was set up in "corridor B" in the southern part of the Great Sand Sea, within the area of Libyan Desert Glass. The corridors — made up of relatively recent gravels and separated by linear dunes — have long provided travel routes in this remote area.

Understanding 'metallic water'

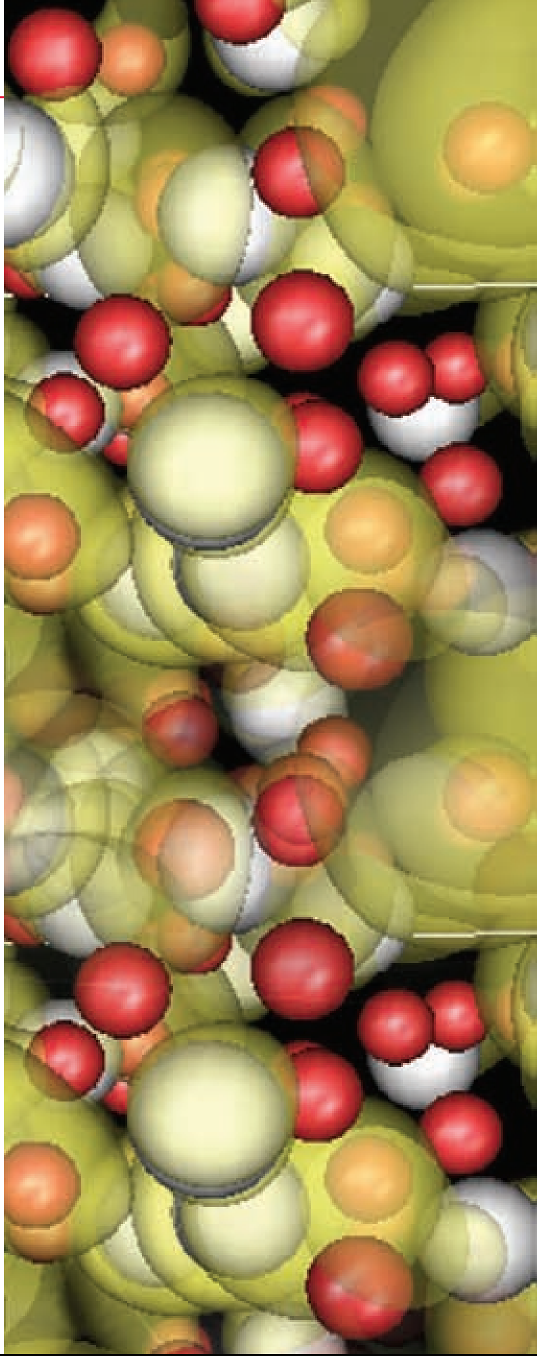
Thunderbird supercomputer simulations by two Sandia researchers have significantly altered the theoretical diagram universally used by scientists to understand the characteristics of water at extreme temperatures and pressures. The surprising results were not the intent of Sandia coinvestigators Thomas Mattsson and Mike Desjarlais.

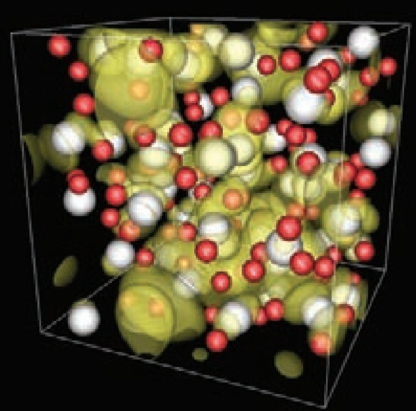
A new computational model developed at Sandia alters significantly the theoretical diagram used to understand water at extreme temperatures and pressures and expands the known range of water's electrical conductivity, according to Labs' researchers Mike Desjarlais and Thomas Mattsson.

The Sandia work shows that phase boundaries for "metallic water" — water with its electrons able to migrate like a metal's — should be lowered from 7,000 to 4,000 kelvin and from 250 to 100 gigapascals of pressure. A phase boundary describes conditions at which materials change state. An example would be water changing to steam or ice. In this instance, water in its pure state — an electrical insulator — becomes a conductor.

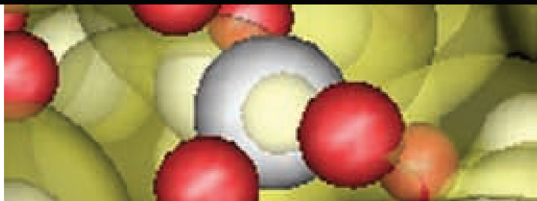
One ramification of the lowered boundary is revision of astronomy calculations of the strength of the magnetic cores of gas-giant planets like Neptune. Because the planet's temperatures and pressures lie partly in the revised sector, electrically conducting water probably contributes to Neptune's magnetic field.

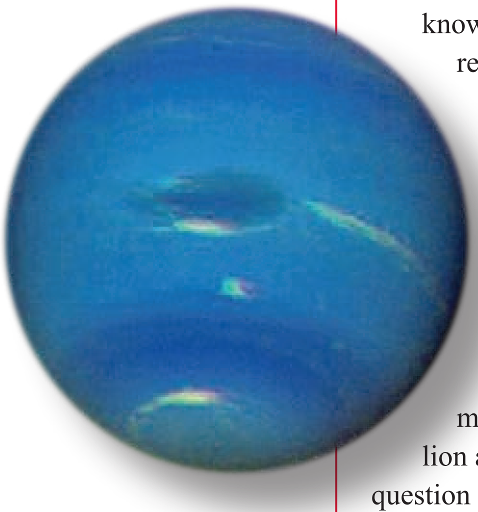
The recent calculations — published in *Physical Review Letters* last summer and presented at the 12th International Workshop on the Physics of Non-Ideal Plasmas, held in Darmstadt, Germany — agree with experimental measurements in research led by Peter Celliers of Lawrence Livermore National Laboratory.





The electrically conducting structure of metallic water occurs at a more accessible part of the water phase diagram than formerly thought. Here, a snapshot from a computer simulation demonstrates the atomic disorder. Red spheres are hydrogen atoms, white spheres are oxygen atoms, and the electron density from a partially occupied electron state responsible for the conductivity is shown in gold.





This view of Neptune, from NASA's Voyager spacecraft, shows its blue-green atmosphere.

The effort began with a look at a specific problem. "We were trying to understand conditions at [a powerful Sandia accelerator known as] Z," says Mattsson, a theoretical physicist, "but the problems are so advanced that they linked to other branches of science."

Z renovation

Sandia's Z accelerator has been undergoing an extensive renovation that will increase the machine's pulse from 20 to 26 million amps — a 30 percent boost. The question to researchers: How will water behave, subjected to these more extreme conditions?

The power Z emits in X-rays when it fires is equivalent to many times the entire world's generation of electricity — but only for a few nanoseconds. The machine creates high temperatures and pressures in water because of the 20-million-amp electrical pulses it sends through a row of water switches. First, the water acts as an insulator, restraining the incoming electric charge. Then, overcome by the buildup, water transmits the pulse, shortening it from microseconds to approximately 100 nanoseconds. This compression in time is a key element of what makes the Z accelerator so powerful.

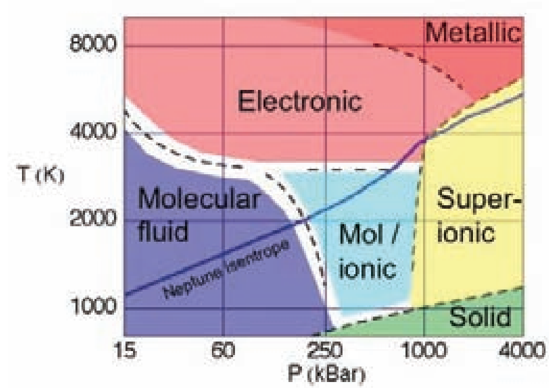
The concern was that the Z refurbishment might go beyond the ability of a water switch to function as designed and carry the required current, says Keith Matzen, director of Sandia's Pulsed Power Sciences Center. "More efficient, larger machines may run into a limit and their switches not meet design requirements. So the question is: how does a water switch really work from first principles?"

One aspect of this knowledge is to model water to get a better understanding of its behavior under these extreme conditions, he says. Mattsson and Desjarlais first found deviations from the standard water-phase diagram when they ran an advanced quantum molecular simulation program on Sandia's Thunderbird supercomputer that included "warm" electrons instead of unrealistic "cold" ones, says Desjarlais.

Molecular modeling code

Desjarlais extended a molecular modeling code, written in Austria, to model electrical conductivity, and Mattsson developed a model for ionic conductivity based on calculations of hydrogen diffusion. An accurate description of water requires this combined treatment of electronic and ionic conductivity.

As it turns out, the newly discovered regime will not adversely affect Sandia's water switches on the renovated Z machine. But water switches not yet designed for future upgrades may require the more accurate understanding of the phases of water discovered by the researchers.



Right: This more recent phase-diagram of water in the high energy-density regime (temperature on the left-hand axis and pressure along the bottom) also shows a calculated Neptune isentrope (blue line.) The isentrope shows conditions and phases moving deeper into the planet and was drawn by Nadine Nettelman, a graduate student with Professor Ronald Redmer, Rostock University, Rostock, Germany.

Because of Z's success in provoking fusion neutrons from deuterium pellets, it is thought of as a possible (if dark-horse) contender in the race for high-yield controlled nuclear fusion, which would provide essentially unlimited power to humanity. Z is more immediately useful for U.S. defense purposes — data from its firing is used to validate physics models in computer simulations to certify the safety and reliability of the nuclear weapons stockpile.

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The skies south of Albuquerque offered a bright surprise in early September when NASA's Marshall Space Flight Center conducted experiments for its In-Space Propulsion Technology Project. Sandia and NASA tested materials under extreme temperatures for new advanced thermal protection systems for aerocapture flight maneuvers.

Solar tower testing supports NASA plan

NASA tests at Sandia's National Solar Thermal Test Facility south of Albuquerque, New Mexico, in September produced dramatic bright light, smoke, some flames, and provided information crucial to the next generation of spacecraft.

Using a specially built fixture to hold samples of new ablative materials, researchers from Marshall Space Flight Center, located in Huntsville, Alabama, mounted the test materials on special arms atop the lab's 200-foot solar tower and exposed them to concentrated solar radiation. The materials scorched in the test were samples of heat shields that NASA plans to use as a new advanced thermal protection system in future spacecraft for aerocapture flight maneuvers.

Aerocapture is a nearly fuel-free maneuver that uses a planet's atmosphere to capture a spacecraft and place it in its desired orbit. Analogous to a rock skipped across a lake, a spacecraft arriving at a distant planet plunges into the planet's atmosphere, which slows the craft and changes its trajectory into an elliptical orbit. A key difference between the rock-on-the-lake analogy is the huge amount of friction this maneuver creates in an atmosphere: hence the material tests at 3,500 degrees F at the solar tower.

Artist concept of a spacecraft using aerocapture to enter an orbit around Mars. (Image courtesy of NASA)

NASA's test took place at Sandia's National Solar Thermal Test Facility, where solar thermal components and systems are developed, researched, and tested. (Photo by Randy Montoya)

The solar tower used its 212 computer-controlled mirrors, called heliostats, to track the sun and focus sunlight on the target, simulating the high heat encountered during an aerocapture maneuver.

"It's worked beautifully," said Bill Congdon, manager of the ARA Ablatives Laboratory, the Colorado-based manufacturer of the advanced materials for NASA. The structure created on the tower high above the New Mexico desert allowed him to test 2-foot by 2-foot panels of material, subjecting the sample to the intense heat of 1,500 suns. "We wanted to make sure it doesn't debond — that's the purpose of this," Congdon said, noting the charred test panel was still in one piece after a blast of heat.

If the concept can be proven effective it can save almost half of the mass usually taken up in a spacecraft by fuel, according to NASA estimates.

Sandia's John Kelton prepares samples of NASA's advanced ablative heat shield materials for a test atop the 200-foot solar tower. The materials are designed to shed heat by thermal consumption of their outer layers as the shielded spacecraft maneuvers within planetary atmospheres. (Photo by Randy Montoya)

Ablation gases rise from a material as it is superheated by a beam from Sandia's solar tower. (Photo by Randy Montoya)

Cheryl Ghanbari, test engineer at the solar tower, subjected the shield materials to their high temperature flight environment, by controlling exposure duration using preprogrammed heliostate movements. Intensity was controlled by varying the number of heliostats used for each test. The Sandia team monitored radiation flux, the intensity of solar energy, using a radiometer that is exposed before and after each test.

Researchers have conducted more than 100 similar tests on samples ranging from 5-inch-diameter pucks to the current 24-inch square samples during the past three years.

Sandia's facility is the only place in the country where NASA can test relatively large objects under such intense heat, said Bonnie James, technology manager of aerocapture propulsion technology at Marshall. The project had evaluated thermal test facilities all over the country, but said that it was difficult to find facilities that could test things "larger than a coupon," a much smaller sample than this test required.

"This is a very unique facility with very unique capabilities," James said.

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For more information:
www.nasa.gov/centers/marshall/news

Sandia – Monsanto Company announce cooperative agreement

Sandia's imaging equipment offers the possibility of better understanding ways to convert cellulose-containing biomass into transportation fuel.

Researchers at Sandia National Laboratories and Monsanto Company, based in Creve Coeur, Missouri, have announced a three-year research collaboration that is expected to play a role in both organizations' interests in biology and bioenergy.

Monsanto Company is a leading global provider of technology-based solutions and agricultural products that improve farm productivity and food quality. The arrangement is aimed at aligning Sandia's capabilities in bioanalytical imaging and analysis with Monsanto's research in developing new seed-based products for farmers that may be able to produce more ethanol per bushel.

Sandia's equipment "offers a unique imaging capability," said Grant Heffelfinger, senior manager of the labs Molecular and Computational Biosciences group. The tool offers the possibility of better understanding ways to convert cellulose-containing biomasss into transportation fuel, he said.

The research, which falls under a larger, "umbrella" cooperative research and development agreement (CRADA), will initially focus on hyperspectral fluorescence imaging and spectral analysis. Researchers from the two organizations will apply Sandia's patented imaging technology to aid in the study of plant tissue samples of interest to Monsanto, the first agriculture company to make use of this cutting-edge approach.

Hyperspectral imaging is an advanced scanning technology that provides significantly more information on a subject of interest than other scanning technologies commercially available today by detecting microscopic images using a continuous spectrum of light.

The shared goal for the partners is to identify components and structure of plants — including grasses, trees, corn, soybeans, and other crops — that can most easily be converted to liquid transportation fuels. Monsanto's crop analytics research program has recently played a role in discovering new products for farmers, including corn hybrids that offer more ethanol output per bushel and soy-

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This first use of the cutting-edge hyperspectral imaging and analysis technology by an agricultural company will support a joint goal — how to identify and develop grains with the highest potential of conversion to transportation fuels.

bean varieties that produce more nutritious oils for consumers.

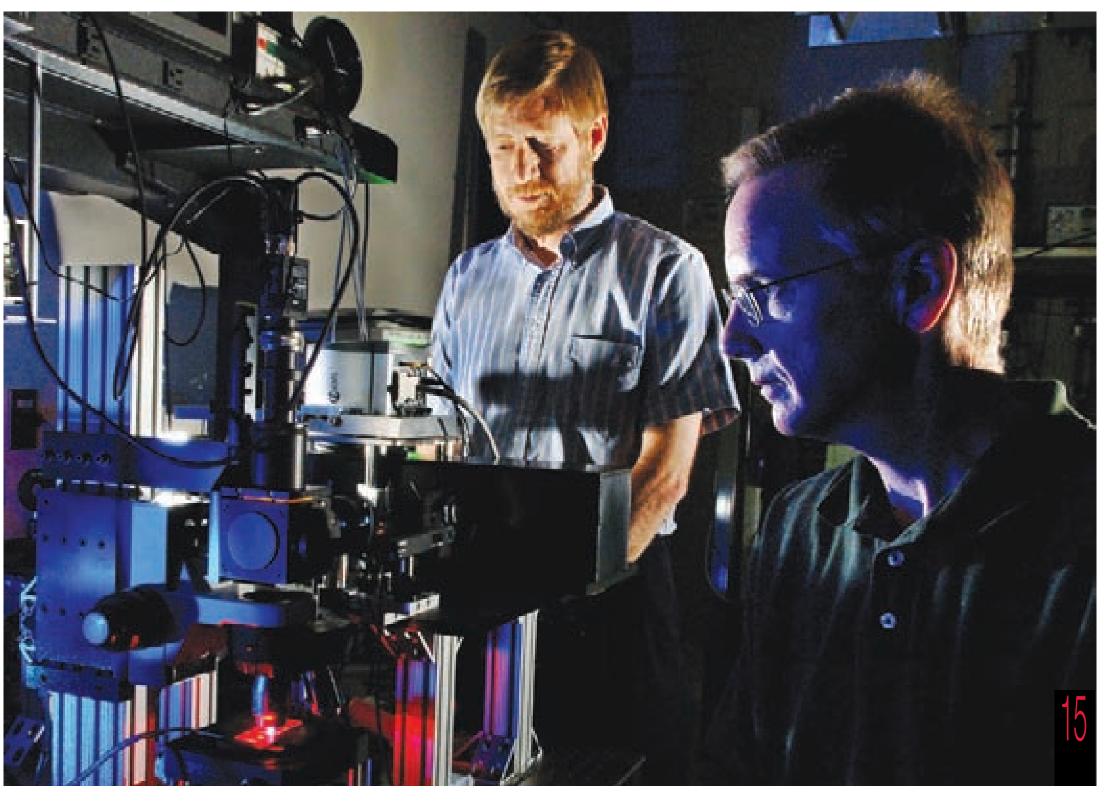
"Seeking out new and innovative scientific tools is an important part of how we bring forward new technologies for the farmer," said Pradip Das, director of Crop Analytics for Monsanto. "This collaboration provides Monsanto with a new opportunity to further augment our existing crop analytics program, offering our researchers another way to better understand genomic profiles for seed and trait development." The tool will save Monsanto labor, cost, and time, Das said.

Sandia researchers in New Mexico will investigate, develop, and further advance the hyperspectral imaging technology and analysis methods and capabilities for agricultural product discovery and development.

"A strategic relationship with Monsanto makes sense on many levels and will bolster our collective long-term objectives in bioenergy and biofuels," said Terry Michalske, director of Sandia's Biological and Energy Sciences Center. He noted that researchers at Sandia's Combustion Research Facility in California could eventually benefit from the CRADA by gaining experience with agricultural samples that have bioenergy/biofuel applications and uses.

Ancillary research focusing on the photosynthetic properties of various plants and microbes, for instance, will add to the laboratory's growing expertise in understanding the conversion of sunlight to sugars, relevant not only to the production of new fuels from biomass but also essential to the global carbon cycle and carbon sequestration.

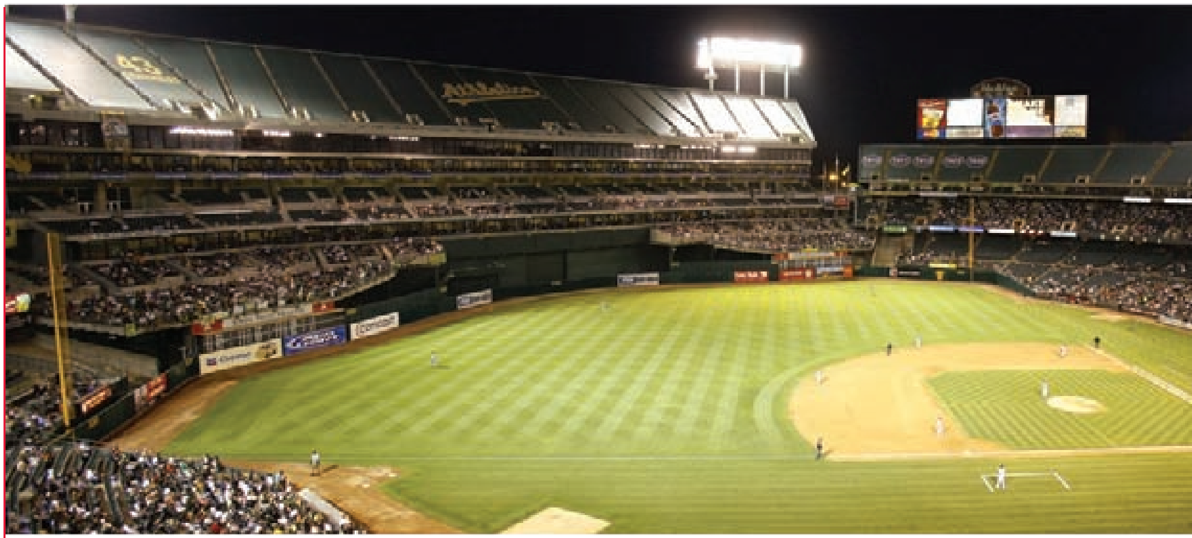
Recent biotechnology endeavors at Sandia have focused on developing and applying biotechnologies to identify early signs of infectious diseases through protein interactions and biomarkers at the single cell and whole organism scale. Sandia is also planning a key role in a multilab/university effort to bring a DOE-funded bioresearch facility to the San Francisco Bay Area.



Sandia researchers Michael Sinclair (foreground) and David Haaland prepare a hyperspectral confocal microscope for measurement of a biological specimen. (Photo by Randy Montoya)

Detect-to-warn system offers lifesaving capability

Scientists from Sandia pondered whether their detection equipment could catch a whiff of a terrorist chemical attack in a morass of other smells. They found out by field testing the equipment at McAfee Coliseum while the Oakland A's battled the Detroit Tigers and Los Angeles Angels. Despite the mélange of cigar smoke, after-shave, hairspray, and ambient odors from the surrounding industrial neighborhood and Interstate 880, the result was successful.



Baseball fans cheering on their beloved Oakland A's in a summer homestand may have been happy about the team's play, but the best news for those visitors to McAfee Coliseum didn't take place on the field and couldn't be noticed by even the most observant spectators.

Through late June and early July, researchers from Sandia National Laboratories in Livermore, California — roughly 30 minutes east of the A's home at McAfee Coliseum — tested the Sensing Nodes Informing and Facilitating Fast Emergency Response (SNIFFER) during a series of games. The system, which can be packaged and deployed locally within 24 hours, was developed for the Department of Homeland Security and is designed to provide swift yet effective protection at high-profile events.

The research verdict: "It was very clean based on what we were expecting," said Ben Wu, a chemical engineer at Sandia who serves as project manager for SNIFFER.

SNIFFER is designed to provide broad, high-confidence coverage of more than 40 different chemicals using multiple overlapping detection technologies and live video. "The beauty of this system is that it can be packaged and set up at a venue within a day's notice, without having to sacrifice any of the robustness or features required by such a sophisticated system," said Wu. "The bottom line is that it can help emergency responders save more lives in the event of a terrorist attack."

SNIFFER can detect a variety of chemical warfare agents as well as the more common toxic industrial chemicals. The SNIFFER platform will also readily accept other types of detectors, such as those that sense radiological material. As a "detect-to-warn" system, said Wu, the aim of SNIFFER is to alert emergency responders to a chemical release early on and enable evacuations or other timely response measures to minimize casualties.

Detection and surveillance mix

A 2004 version of SNIFFER (then reported in *Sandia Technology* as Sensor Management Architecture) used just one "node," a box laden with electronic components, detectors, and communications equipment, and just two detectors. The SNIFFER system has matured to the point that eight nodes, totaling some 64 detectors, were networked in and around McAfee Stadium during the Oakland deployment.

The detectors, said Wu, use a variety of technologies and capabilities in order to counter any attempts by outside forces or terrorists to tamper with the system, and simply to avoid having to rely too heavily on any one detector. Detectors are placed strategically and, depending on wind trajectory and other environmental variables, might even be placed outside a venue's physical boundaries.

The system also incorporates video surveillance cameras, which serve both to confirm the findings of the detection equipment and to keep a lookout for illicit attempts to damage or alter any system components.

In designing and testing the SNIFFER system for DHS, said Wu, the main obstacle has been in dealing with the plethora of "background noise" common in or near large venues — one reason why Sandia's team appreciated McAfee Coliseum management allowing a multigame test deployment there.

"You simply can't reproduce in a laboratory the kind of real-world environment in which SNIFFER is meant to be deployed," Wu said.

Special events

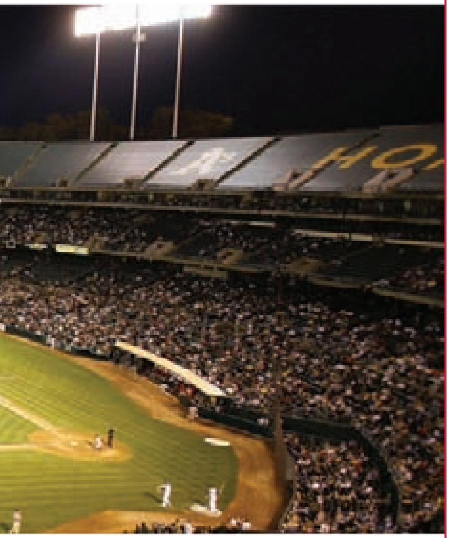
In a typical sports venue such as McAfee, he said, detectors must try to differentiate between authentic chemical releases and cigarette smoke, automobile emissions, perfumes, odors from popcorn machines, hamburger stands, and hot dog vendors.

While indoor spaces concentrate smells and chemicals, such as floor waxes and cleansers, homeland security officials wanted to learn about open-air venues — especially those used for special events,

SNIFFER is designed to provide quick yet effective protection at high-profile events.

such as the Super Bowl and the Olympics. The goal over the next few years is to build a network of chemical sensors that require little attention but can sniff an dangerous chemicals in time to quickly warn venue operators to activate emergency response measures.

In addition to the deployment at McAfee Coliseum, Sandia evaluated SNIFFER during a 10-week stint at Sandia's Livermore site and at a brief deployment at San Francisco International Airport in early 2005.



Chemical detection system can detect chemical warfare agents as well as common toxic chemicals.

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Keeping oil and gas control systems safe

LOGIIC team members Bryan Richardson and Weston Henry, standing, demonstrate the project's monitoring solution hosted at Sandia's Center for Control Systems Security. (Photo by Randy Montoya)

Sandia has taken the role as the lead national lab in Project LOGIIC. The project, Linking the Oil and Gas Industry to Improve Cyber Security, was created to keep U.S. oil and gas control systems safe and secure, and to help minimize the chance that a cyber attack could severely damage or cripple America's oil and gas infrastructure.

The concern: An attack by viruses, worms or other forms of cyber terrorism on oil and gas industry process control networks and related systems could destabilize energy industry supply capabilities and negatively impact the national economy.

LOGIIC was funded by the Department of Homeland Security's Science and Technology Directorate. The program brought together 14 organizations to identify ways to reduce cyber vulnerabilities in process control and SCADA (Supervisory Control And Data Acquisition) systems. The goal of the project was to identify new types of security sensors for process control networks.

Sandia worked with project partners to create a simulation test bed and apply this environment to counter potential threats to the oil and gas industry using hypothetical attack scenarios. Sandia researchers created two real-time models of control

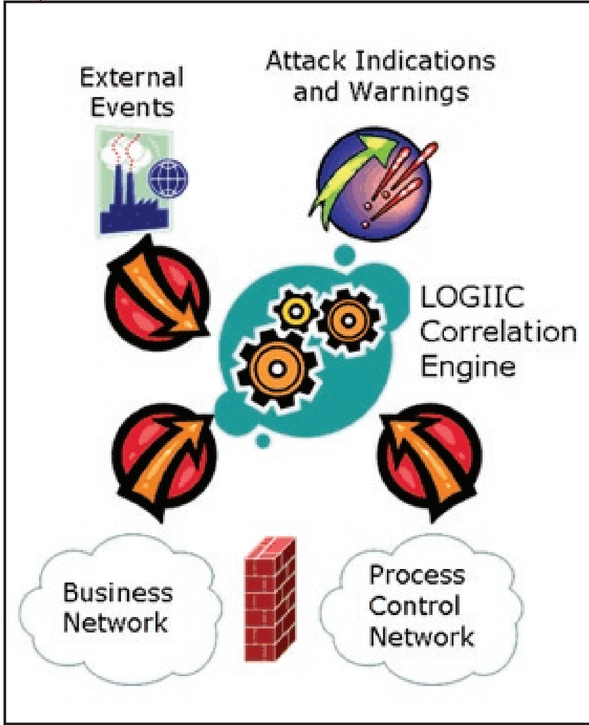
"Without monitoring, it's difficult to detect cyber adversaries, who might be attempting to compromise critical system components."

— Ben Cook
LOGIIC project leader

systems used for refinery and pipeline operations.

Ben Cook, project lead for Sandia, said LOGIIC brought together government, asset owners, vendors, and the research community to protect the critical infrastructure. A key element of LOGIIC's public-private partnership model was the leadership role it gave to industry partners — in this case the oil and gas asset owners — to define the technical problem and manage the project towards a successful outcome.

"Current control system operators have limited situational awareness," he said. "In LOGIIC, industry leaders chose to focus the partnership team's initial work on addressing their concern that control networks aren't monitored for cyber intrusions as is routinely done on business networks. Without monitoring, it's difficult to detect cyber adversaries, who might be attempting to compromise critical system components.



The monitoring system developed in LOGIIC is based on the latest commercial enterprise detection and correlation technologies adapted to monitor control networks, providing asset owners with dramatically improved awareness," Cook said.

To test LOGIIC's monitoring capabilities, Sandia researchers came up with five vulnerability scenarios based on cyber compromises commonly used in the hacker community. Ray Parks, who led the development of the scenarios, used his background as a member of Sandia's cyber red team, which has performed numerous vulnerability assessments of oil and gas and other critical infrastructure facilities.

LOGIIC included experts in homeland security, oil and gas, security research, security technology, and process control technology.

Project results were shared this fall at the LOGIIC Summit in Houston, Texas. The meeting showcased results and promoted the partnership model as a template for future public-private partnerships to improve infrastructure security. A field test of the LOGIIC solution is planned.

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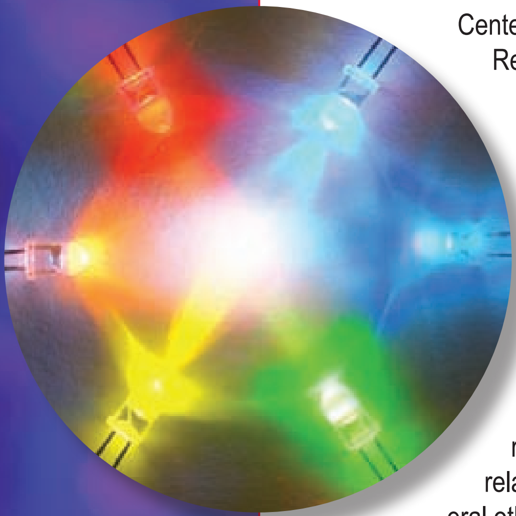
The LOGIIC website:
www.logiic.org

NEWS NOTES

DOE selects Sandia Labs as Solid-State Lighting Center



The mixture of light from LEDs of multiple colors creates white light with a high color rendering quality.

Courtesy of Fred Schubert, RPI

Sandia National Laboratories is the new home of the National Laboratory Center for Solid-State Lighting Research and Development. U.S. Department of Energy (DOE) Secretary Samuel W. Bodman made the announcement at a news conference at Sandia's International Programs Building in October.

Sandia will conduct vital solid-state lighting research and coordinate related research efforts at several other national laboratories.

DOE will provide funding of $5 million for seven research projects in solid-state lighting, including $2.6 million for four Sandia projects, Bodman said. The funding comes from DOE's Office of Energy Efficiency and Renewable Energy.

"The research will be conducted at the new nanotechnology centers at our national laboratories," Bodman said, including the just dedicated Sandia/Los Alamos Center for Integrated Nanotechnologies (CINT). "This is part of nearly $20 million we are committing this year to support research and development efforts in this rapidly emerging technology."

Bodman laid out the case for investment in solid-state lighting R&D, noting that 18 percent of all U.S. energy generated — valued at $55 billion — goes to lighting homes, offices, and factories. "We believe a set of revolutionary new technologies, called solid-state lighting, offers excellent prospects for meeting our future lighting needs in a less costly, more efficient way than today's incandescent and even fluorescent fixtures," Bodman said.

"We also believe that solid-state lighting presents an excellent opportunity for the U.S. to assume a leadership role in an emerging industry that can generate thousands of high-paying, high-quality jobs in the years ahead and help maintain the U.S. economy's strong record of global leadership in growth and jobs creation."

U.S. Sen. Jeff Bingaman said he hoped the tens of thousands of high-paying jobs that will emerge in this budding industry in the next few years will stay in the U.S., rather than go overseas. "It makes sense that this research will be done right here at Sandia, where scientists are already hard at work developing this technology."

U.S. Sen. Pete Domenici praised DOE for making the investment in solid-state lighting research. He said there are many ways the nation can address the issue of the overconsumption of crude oil from overseas. He predicted a bright future for solid-state lighting. "There will be spin-offs" from this research, he said, and the labs involved will find "the longest waiting list they've ever seen" for partners from industry and academia eager to collaborate on research projects.

Jerry Simmons, left, senior manager of Sandia's Energy Sciences Department briefs visitors, including DOE Secretary Samuel Bodman. Shortly after, Bodman announced that the Center for Integrated Nanotechnologies at Sandia is the new home of the National Laboratory Center for Solid-State Lighting Research and Development.
(Photo by Randy Montoya)

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LDRD

"The initial investment blossomed into a real success story, and a fundamental strong element of that was the engineering. It's gone a long way. . . . We have great science here, and we also have great engineering to enable the science. More than 20 second-generation MicroChem-Lab boxes relying on these technologies are currently used in Sandia programs."

Ron Renzi,
Sandia microsystems engineer

Sandia National Laboratories

LOCKHEED MARTIN

Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000

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