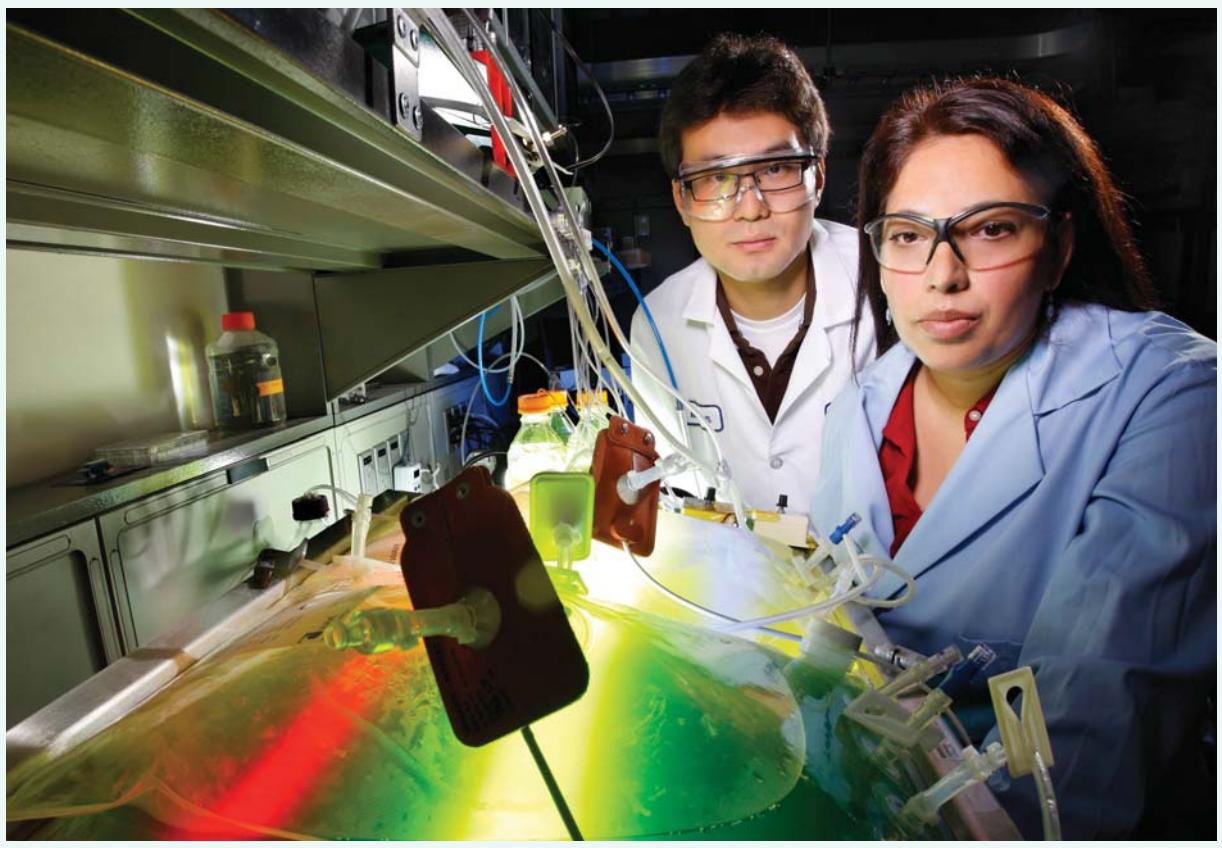
Pinpointing lipid accumulation in algae

By Patti Koning



Algae has great promise as a potential source of biofuel — it grows easily and abundantly and can be rich in triacylglycerols, a lipid that can be extracted and converted into fuel. But after 30 years of research, little is known about the mechanism that produces triacylglycerols, the missing link that could take us from algae to "oilgae."

"Certain algae are known to be really good candidates because of their lipid accumulation," says Blake Simmons (8630). "One of the biggest problems is a lack of fundamental understanding about how these algae do what they do, what environments they do it in, and how we can manipulate them to make them more attractive from a biofuel production standpoint."

Sandia researchers may have found the key to solving that problem with a new method of analyzing algae at the cellular level. Over the past two years, Seema Singh (8634) has led a Laboratory Directed Research and Development (LDRD) project to develop

(Continued on page 4)

CATCH AND RELEASE FOR ALGAE — Using laser trapping Raman spectroscopy, Huawen Wu and Seema Singh (both 8634) are able to analyze lipid accumulation in a single algae cell without changing or harming it, something not possible with conventional methods. This technique will greatly accelerate research into candidates for algal biofuel production. (Photo by Randy Wong)

Living in Livermore

Life at Sandia/California has its own distinct flavor and tempo. Catch the beat in a photo essay on **pages 6-7.**

California Sandia LabNews

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Sandia National Laboratories

Fuel cell mobile lighting system featured at final space shuttle *Atlantis* launch

By Mike Janes

Fuel cells were used in the space shuttle as one component of the electrical power system, so perhaps it was appropriate that a hydrogen fuel cell-powered mobile lighting system could be seen on the grounds of the Kennedy Space Center as the space shuttle *Atlantis* launched into orbit last month for the 135th and final mission of the NASA Space Shuttle Program.

The lighting system, sponsored by the DOE's Office of Energy Efficiency and Renewable Energy (EERE) in conjunction with Boeing Co., and developed by Sandia and several industry partners, was deployed to the site of the final space shuttle launch and observed by visitors, shuttle astronauts, and members of the international media.

The unit provided lighting in the international press area, and its auxiliary power was used to conveniently recharge the camera battery packs for a number of photographers at the event. The NASA deployment was the latest in a series of high-profile test sites where the lighting system has been utilized.

The hydrogen fuel cell-powered mobile lighting system is a clean, quiet, and efficient alternative to traditional technologies commonly powered by diesel-fueled generators. The system features a fuel cell running on pure hydrogen, resulting in zero-emission electrical power. The fuel cell produces electricity for an advanced, power-saving Light Emitting Plasma™ (LEP) lighting system and additional auxiliary

(Continued on page 4)

LIGHTS . . . CAMERA . . . ACTION — A hydrogen fuel cell-powered mobile lighting system developed by Sandia and several industry partners was deployed to the site of the final space shuttle launch July 8 and observed by visitors, shuttle astronauts, and members of the international media. (Photo by Steffan Schulz)

Inside . . .

That's that

By Patricia Schuster

Ahhhh - to be an intern. It's the life, huh? You show up for four months, live in an empty apartment, build furniture out of refrigerator boxes, do a little project, then head back to school. As an intern, you get to preview what life is like in the "real world," which seems like a great place. It has health insurance, free time at night, and paychecks. A good deal all around.

PATRICIA SCHUSTER

Having grown up in Michigan and lived there all my life, the move to California was very exciting. The landscape is incredible, the sun is always shining, and there are a million things to do. Livermore is a great place to stay for a summer. It's almost like a long-term weekend getaway. The downtown is filled with local restaurants (including a 24-hour doughnut shop), and the people are friendly and helpful. Once while biking home, I rode almost two miles behind another biker, and when he turned off the main road he looked back at me and said, "Take care now!" But I'd have to say the best part about living in Livermore is Mr. Pickle's, a local sandwich shop. Their food is great, but even better is the mascot who, dressed as a giant pickle, stands on the corner outside and dances all day long. That might be the source of the contagious happiness here.

My experience at Sandia has been excellent. Compared to my past internships, I found the work challenging and exciting, the lifestyle relaxed and active, and the people happy and content. Even walking across the site is like going to the zoo. The lizards dash in front of you and the squirrels all run back into their tunnels. I hear the New Mexico site even has prairie dogs — how cute are they? A major benefit to being a Sandia intern is meeting students from schools all over the country. With more than 100 interns at the California site alone, I've been able to learn about many different programs and research topics.

Ultimately, though, being an intern isn't just about a four-month vacation in California. It's about forming a partnership between national laboratories and universities. Other countries are advancing their university systems and their technological expertise, and many believe the US will soon fall behind. To maintain our advantage, it's important to bring more students into technical fields, especially research and development. Although there are no more Harry Potter movies to look forward to, the future is still bright for our country. By encouraging students to pursue technical careers, the US will maintain its exceptional scientific workforce and continue leading the world in technical advancements.

The academic atmosphere at Sandia makes it one of the best environments for students to intern. Not only are the mentors brilliant and eager to help, but the work is just about as cutting edge as it gets. During my time working with Radiation and Nuclear Detection Systems Dept. 8132, I worked on a project that uses a system of four rotating detectors with time-encoded imaging to locate a neutron source. I had done similar work in my research projects at school, but none of the approaches were as clever or original as this. The task of locating and identifying a threatening source in a timely manner has proven a great challenge to many physicists and nuclear engineers. To learn directly from scientists here at Sandia who are tackling the problem in a unique way was a great learning experience for me, and has encouraged me to pursue research on this topic in the future.

This month, you might notice that there are a few extra doughnuts at the staff meetings, a few less out-of-state license plates, and a few less people stuck in the turnstiles trying to figure out how to swipe their badges. As your interns leave, remember that you have provided them an opportunity to grow, both as people and as scientists. I hope to come back to Sandia in the future and continue working with my group to provide exceptional service in the national interest.

* * *

Patricia Schuster worked with mentor Scott Kiff in Radiation and Nuclear Detection Systems (8132) at Sandia/California. She earned her B.S.E in nuclear engineering and radiological sciences at the University of Michigan in May 2011 and will start this fall as a PhD student in Nuclear Engineering at UC-Berkeley. She hopes to continue research with her group at Sandia during the school year through the National Science and Security Consortium.

New Center 8200 director Russ Miller rich in experience

New Center 8200 director Russ Miller brings to the job an almost unparalleled depth of experience in nuclear weapons programs at Sandia. Name a weapons program developed since 1976, when he joined the Labs, and chances are he's had a hand in it.

Russ broadened that experience in his most recent assignment, as NNSA's technical liaison for Air Force Global Strike Command (AFGSC) at Barksdale Air Force Base, a position he held from January 2010 through June 2011.

"One of the most rewarding aspects of this assignment was the ability to give back to my country," he says. "I have not been a member of the armed services and I was at a point in my career to make a commitment like this."

AFGSC, the first new Air Force major command in 26 years, organizes, trains, and equips combat-ready forces for nuclear deterrence and global strike operations — safe, secure, effective — to support the US president and combatant commanders. In his role, Russ served as a liaison/technical reachback to NNSA and the three nuclear weapons laboratories for the Air Force.

RUSS MILLER

"This command has responsibility for all Air Force nuclear weapons systems, whether they are ICBMs, bombs, or cruise missiles," Russ says. "Being able to contribute to that command and help it succeed has given me great professional and personal satisfaction." He was presented with the Department of the Air Force Award for Meritorious Service upon his departure from AFGSC.

A career in weapons work

Russ has worked in nuclear weapons for nearly all of his 35 years at Sandia. His first assignment was as the firing system engineer for the W84 warhead. Since then, he's been involved in most major weapons programs, including the W89, W87, B83, W62, Joint Test Assembly (JTA), the Reliable Replacement Warhead (RRW), and the Reentry System Transformation Program. Most recently, he was senior manager of advanced and exploratory work in the California Weapons Systems Engineering Center.

"My passion is around creating and developing new things," says Russ. "Helping develop the LEP concept in the early 1990s was a challenge I found quite rewarding, along with RRW more recently. I was among the first staff at AFGSC and was able to create the roles and responsibilities for the technical liaison position."

His first priority as Center 8200 director is staff development. "It's been five years since the last major program, the W80 LEP, was executed in California. Since then there has been a lull in large systems engineering efforts at the site," explains Russ. "So we need to reinvigorate those efforts and bring into the workforce people who are capable of executing that mission."

Over three years, starting in 2010, essentially 40 percent of the center's workforce will be hired — nearly 100 people. The center is in a period of growth with authorization of the W78 LEP, currently a phase 1 conceptual design effort that Russ anticipates will become a full scale development program for the Air Force.

His second priority is to instill a science-based engineering competency in Center 8200. "We now have materials science and engineering and modeling and simulation in this center," explains Russ. "The staff needs to fully utilize those capabilities as part of the way they normally do their job. I want everyone to find the engineering environment exciting, stimulating, and supportive."

His final priority is developing programs and delivering on commitments. "It's not my role to engineer things but rather to provide a vision and enable the staff to succeed," he says. "I'm looking forward to exciting and challenging work that will reinvigorate staff and give them a sense of accomplishment."

Russ and his wife, Maureen, have five adult children, ranging in ages from 19 to 27 years. As a family, they enjoy boating and camping in the Sierras.

Sandia LabNews

Sandia National Laboratories

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Sandia CaliforniaNews

It's become an August tradition. For the fifth consecutive year, this special edition of the *Lab News* is dedicated largely to the work being done today at Sandia/California. The issue's guest editors are Mike Janes and Patti Koning.

Quick thinking . . .

Sandia researcher's recruiting mindset leads to successful partnering on $25 million NNSA consortium award

By Mike Janes

Last year, NNSA put out a call to universities in hopes of generating academic partnerships with national laboratories that could help train future nuclear scientists. Peter Marleau (8132) quickly put on his recruiting cap.

"The other physicists in my group and I are always looking for opportunities to remain active with our alma maters and get fellow graduates to come to Sandia," Peter says. "I saw this as a way to get back in touch."

A University of California-Davis graduate, Peter called his former adviser and briefed him on the announcement. Calling the effort the "National Science and Security Consortium," NNSA sought proposals from universities that would collaborate with national laboratories to support the nation's nuclear nonproliferation mission through the training and education of experts in the nuclear security field.

"Investing in the scientific and technical underpinnings of our program is critical to implementing the president's nuclear security agenda and to preventing nuclear terrorism and nuclear proliferation," says Anne Harrington, NNSA deputy administrator for Defense Nuclear Nonproliferation. "As we push the boundaries of science and discovery, partnerships like the National Science and Security Consortium are a vital part of our effort to invest in the future of our programs by building a strong pipeline of new technical talent to our laboratories."

Peter's UC-Davis adviser sprang into action, engaging colleagues at other universities to see whether there might be an opportunity for a collaborative proposal. He found out that UC-Berkeley had a proposal in development; UC-Davis was eventually invited to join.

"It turned out that we had connections with UC-Berkeley's nuclear engineering department," Peter says. "Plus, our work here at Sandia/California with radiation detection tied in nicely with the nuclear instrumentation aspects of UC-Berkeley's proposal. So our involvement made a lot of sense." He also points out that Sandia's Livermore site sits neatly between the UC-Berkeley and UC-Davis campuses, making it an even more ideal national laboratory partner for the two schools.

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)

Sandia's role helped lead to UC-Berkeley's winning proposal to the tune of $25 million over five years. The multi-institution consortium includes more than 100 researchers from Michigan State University, UC-Davis, UC-Irvine, the UC Institute on Global Conflict and Cooperation (IGCC), the University of Nevada-Las Vegas, and Washington University in St. Louis. These researchers will collaborate with four DOE laboratories, including Sandia.

Peter says it's likely that UC-Berkeley will take advantage of Sandia's work in neutron imaging systems for nonproliferation, including its well-known neutron scatter camera (*Lab News*, April 10, 2009). That could be manifested through a graduate-level class on nuclear instrumentation, one in which the students build a scatter camera themselves. Sandia research staff would help oversee such an assignment, of course.

"Our skill set at Sandia in fast neutron imaging is very complementary to UC-Berkeley's needs, since they tend to work more on gamma rays," says Peter. "We use similar techniques but look at different kinds of particles, so we should be able to bolster our capabilities by working together."

Research students involved in the consortium will likely be invited to Sandia to work on projects or thesis activities, with Sandia staff serving in advisory roles. Likewise, Sandians may teach at UC-Berkeley or UC-Davis in adjunct professor roles.

Peter says the consortium team is still identifying students who will participate, though one current summer intern — Patricia Schuster (8132), who will enter UC-Berkeley's nuclear engineering program this fall — will be funded by the consortium and will likely return to Sandia. Lectures and presentations to students are planned in the fall to help introduce more students to Sandia and the Labs' work in nonproliferation. "We need to develop interest on the part of the students and get them excited about the work," Peter says.

In the meantime, Peter is excited to help develop the skills of young scientists who can eventually serve the US national interest.

"The intent here is to find researchers who can work for the national laboratories later on and help fulfill the nonproliferation mission," he says.

Sandia NewMexicoNews

Written on the wind

Earlier this month, Sandia hosted its biennial Wind Turbine Reliability Workshop, which brings together industry experts, academics, and other researchers involved in all facets of wind turbine development, manufacture, operation, and regulation. Speakers at the conference included Steve Chalk, deputy assistant secretary for renewable energy in DOE's Office of Energy Efficiency and Renewable Energy (EERE), and Jon Wellinghoff, chairman of the Federal Energy Regulatory Commission (FERC), which oversees US wholesale electric transactions, interstate electric transmission, and gas transportation in the US.

During this year's workshop, Sandia released initial component and system reliability information gathered from a subset of the US wind turbine fleet. The workshop also highlighted related work, such as grid integration. Grid integration research involves investigating the challenges and opportunities associated with integrating a higher percentage of variable renewable energy sources, such as wind and solar, into the nation's electric power grid.

In the photo at left, conference chairman Roger Hill of Water Power Technologies Dept. 6122 and FERC chairman Wellinghoff discuss wind turbine blade efficiency and design. (Photo by Randy Montoya)

Algae

(Continued from page 1)

a real-time in situ method for lipid profiling using laser-trapping Raman spectroscopy (LTRS). While the LDRD project is studying microalgae, the method is universal and can be used for several applications in the field of lipidomics.

"We believe our method has the potential to transform the field of algal biofuel research," says Seema. "Now we can analyze a single cell's chemical fingerprint, not just once, but over and over and examine how different factors affect lipid production. The overarching goal is multifactorial correlation of biotic and abiotic factors to algal growth and lipid accumulation."

The method combines two existing technologies — laser trapping and Raman spectroscopy — that have been widely used for many years. The novelty of Seema's approach is bringing the two together to study algae.

After months of work to select the best algae candidates, the team began with Raman spectroscopy as a way to develop chemical fingerprints of single-cell algae. "The 'ah-ha' moment came when we were saying it would be great if we could just observe these events on a single-cell basis," Blake says. "Then we realized we could, that the technologies had been demonstrated separately, but that no one had combined these techniques for analyzing lipids in microalgal cells before."

Seema brought postdoc Huawen Wu (8634) onto the project because of his experience using LTRS to study lipids in human cells. Algae, he says, are comparatively easier because their lipids are more abundant.

The laser immobilizes a single cell in an optical trap; once immobilized, the cell is interrogated with a Raman spectroscopy system. "You can see what lipids are present, the degree of unsaturation, and even the relative quantitation of the absolute lipids present. Then you let the cell go," Blake explains. "It's basically a catch-and-release program we developed for algae."

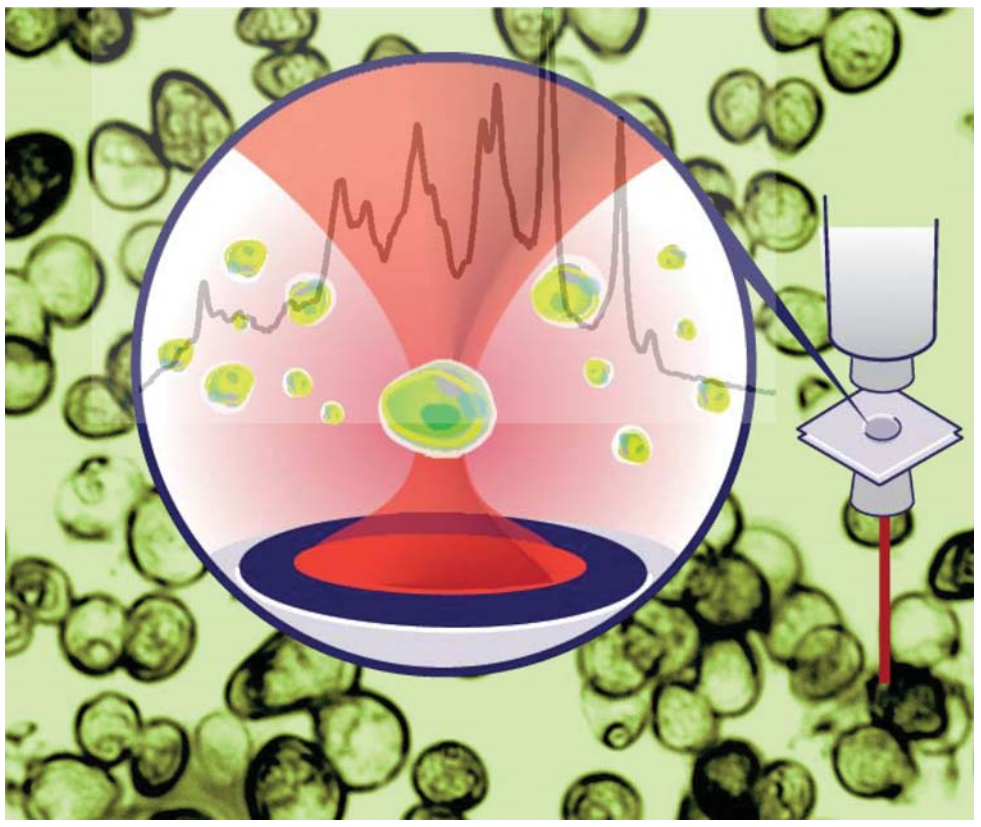
That catch-and-release aspect is important because other methods can significantly perturb and even destroy the algae in the process of analysis. Two methods are commonly used to study algae today — extraction and fluorescence labeling.

In the extraction method, researchers grow and harvest algae, and then extract the lipids to analyze them. And then start over. The process is slow, involves tricky chemicals and laborious fractionation, and ultimately doesn't yield much specific information unless you use very expensive mass spectrometry equipment.

"It's an Edisonian, empirical approach that doesn't easily get down into the important details of lipid composition in the algae," says Blake.

The fluorescence labeling method doesn't fare much better. "It's a brute force method," says Blake. "The dye doesn't like being in water, so it partitions to the lipid within the algae. You can then use that signal as the dye is taken up by the cell to get a rough metric of how much lipid is there. You still don't know what kind of lipid or how much, and it doesn't work for all cells. And it's toxic to the algae."

To exacerbate the problem, algae themselves are rich in fluorescent pigments and create interference. Sometimes they are just too bright to be seen clearly under a fluorescent microscope.



GOTCHA — A single algae cell trapped in using laser trapping raman spectroscopy.

In contrast, the LTRS method is fast, yielding a complete analysis within a few seconds, and insensitive to culture conditions. A researcher can repeat the analysis over and over within the same sample while adjusting parameters.

"You can grow a culture, test it at one temperature and again at an increased temperature, or even as the culture is getting warmer," says Seema. "We're able to track these changes, get a handle on the fundamental biological process of lipid production, and establish a constitutive relationship between growth conditions and lipid yield and profile."

This method also allows researchers to quickly amass hundreds of data points, which then enable the development of algorithms to conduct a ratiometric analysis of lipid, chain length, and degree of unsaturation.

"At the outset, we wanted to demonstrate the ability to grab a cell and understand its total profile. Then we got greedy and began wondering if we could use this method to predict melting temperature," says Seema.

"Now we can use this calibration plot for predictions. You bring me any algae, or any other cell for that matter, and we can probe it and make a prediction on its melting temperature within plus or minus 1 degree. This allows us to gain insight into a particular algae's suitability for a biofuels application."

Because of Sandia's unique experience with Raman spectroscopy for microalgae, the corporation is now partnering with BaySpec to commercialize a pond-deployable algal analyzer.

The project received a phase one National Science Foundation Small Business Innovation Research grant and Seema is hopeful it will be funded for phase two.

This work was published in the March 2011 issue (vol. 108, 3809–3814) of the *Proceedings of the National Academy of Sciences USA*. The research also was recently highlighted by the Nature Publishing Group and the LIPID MAPS consortium in the March 23, 2011, article, "Techniques: Lipids probed by Raman spectroscopy in living cells."

"One beauty of this method is it isn't limited to

Fuel cells illuminate *Atlantis* launch

(Continued from page 1)

power up to 2.5 kW, which allows additional equipment (such as power tools, public address systems, or security metal detectors) to be powered by the unit at the same time the system is providing illumination.

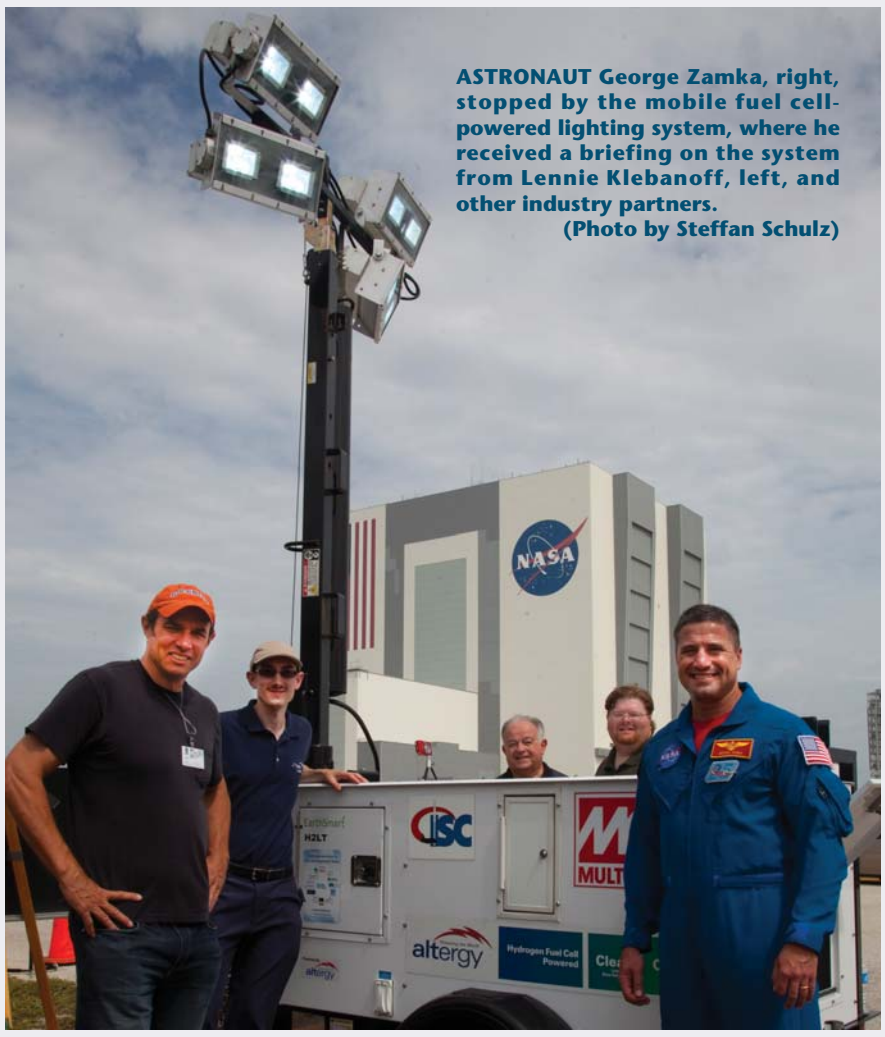
Current mobile lighting typically uses diesel generators that produce greenhouse gases such as carbon dioxide and nitrogen oxides, which produce pollutants and create smog and soot, making them environmentally objectionable. In addition, diesel units are noisy and can create a safety hazard when construction personnel are distracted and cannot hear oncoming traffic.

Sandia researchers estimate that a single hydrogen fuel cell-powered lighting system would offset 900 gallons of diesel fuel per year and completely eliminate soot and nitrogen-oxide and carbon-dioxide emissions, allowing the system to be used indoors in contrast to current diesel technology.

"This hydrogen fuel cell-powered mobile lighting system has the very real potential to drastically reduce dependence on diesel-fueled mobile lighting across the United States and abroad," said Lennie Klebanoff (8367), Sandia's project lead.

The prototype system has been tested in a variety of environments and has primarily focused on the entertainment, transportation, and airport sectors. In addition to NASA (which also used the system during the space shuttle *Endeavor* launch) customers who have provided test sites include the California Department of Transportation, the 2010 Academy Awards® ceremony, the 2011 Golden Globe Awards, the 2011 Screen Actors Guild Awards, and the 2011 Grammy Awards. Boeing, the San Francisco International Airport, and Paramount Pictures will soon be deploying units as well.

In addition to the DOE's sponsorship and Sandia's design and technical management role, the industry partners on the project include Boeing, Multiquip Inc., Altergy Systems, Luxim Corp., Lumenworks Inc., Stray Light Optical Technologies, Golden State Energy, and Ovonic Hydrogen Solutions. The California Fuel Cell Partnership has provided support on hydrogen fuel for several deployments. Multiquip is implementing a manufacturing and commercialization plan for the system.



ASTRONAUT George Zamka, right, stopped by the mobile fuel cell-powered lighting system, where he received a briefing on the system from Lennie Klebanoff, left, and other industry partners.
(Photo by Steffan Schulz)

Sandia assesses supply chain risk for Department of Homeland Security

By Patti Koning

We all live with risk. You could say it's as certain as death and taxes, but when it comes to assigning a definition to risk, things get fuzzy. Risk means different things to different people, and if risk is inherent, how do you decide how much is too much?

Those are questions that Sandia is trying to answer for the National Cyber Security Division (NCSD) of the Department of Homeland Security (DHS) in a study of supply chain risk management.

"We are working to help DHS stand up a supply chain risk management capability for the federal government," says Noel Nachtigal (8958), the project's principal investigator. "Supply chain, in this case, means the complete lifecycle of a piece of equipment from manufacturing of parts to disposal."

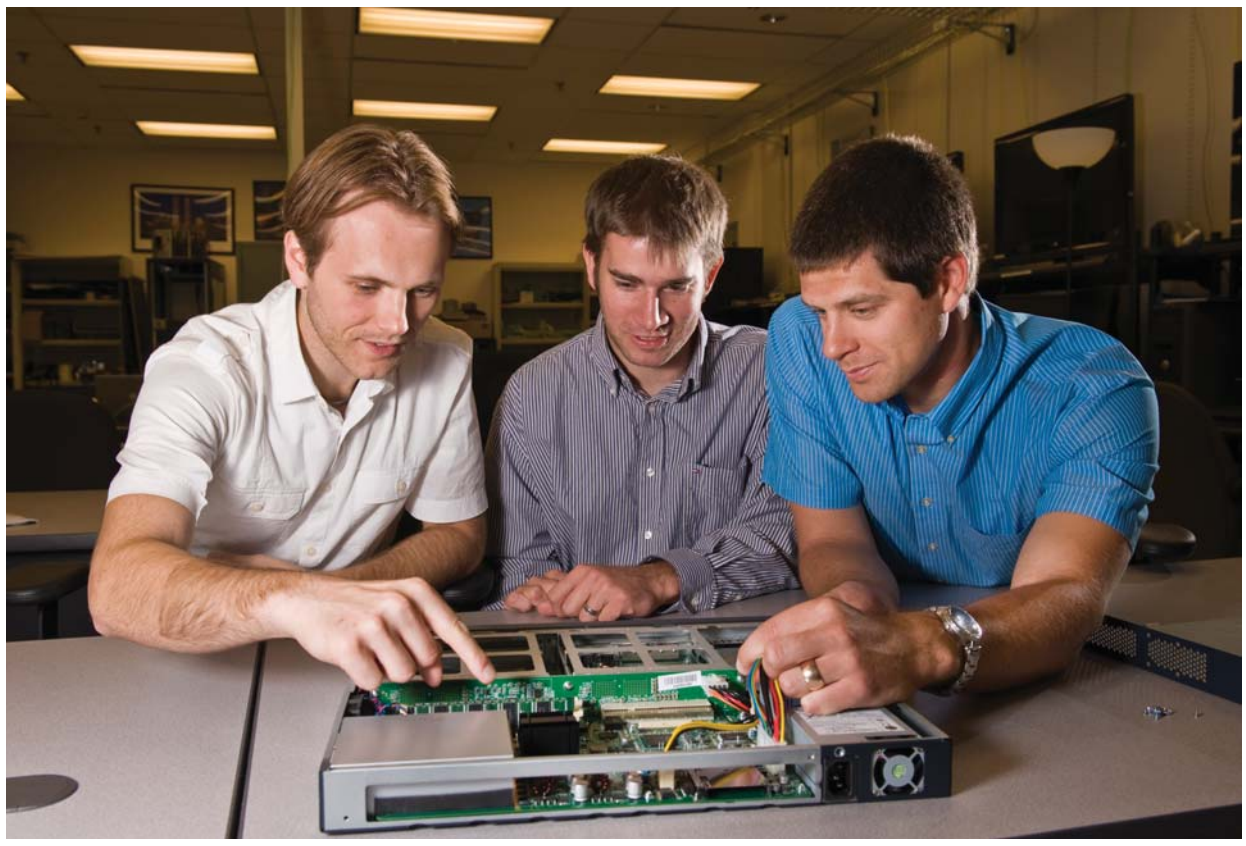
Analyzing supply chain risk, in the case of a laptop computer for example, could mean assessing the risk created by buying from a known versus unknown vendor, whether you have the machine maintained in house or by the manufacturer, downloading firmware updates, and the disposal method. "Specific risks depend on the circumstances," says Noel. "When you start brainstorming risk, the only limitation is your imagination."

In this project, Sandia has provided supply chain risk management analysis for pilot studies on routers for the national telecommunications infrastructure, smart meters in Vermont, and BlackBerry security software. While studying specific products is important, the bigger picture is to help DHS develop language for acquisition contracts and policy recommendations that address risk on a broad scale.

Exploring 'what-if' scenarios

Navid Jam (8965) led the routers pilot. "Large telecommunications companies are significant providers of government services," he says. "The question is, what happens if those companies procure routers from an unknown vendor, either domestic or international? Is going to a source where the integrity of the supply chain may be unknown putting us at greater risk?"

In this pilot, Navid's team studied the hardware of different routers by analyzing the components, looking at their function, where they were made, and what was known about the manufacturers. They also explored "what if" scenarios, devising ways in which the routers could be compromised, the risk posed, and ways to mitigate the risk.



RISKY BUSINESS — David Zage (9516), Abraham Clements, and Jason Haas (both 5621) are members of a Sandia team working with the Department of Homeland Security on a study of supply chain risk management. (Photo by Randy Montoya)

"If the answer is yes, that buying from an untrusted source creates risk — which is not yet clear — then what can you do about it? What do you need from a policy and acquisition point of view?" says Noel. "We're providing technical advice to inform these decisions."

For the state of Vermont, Sandia provided technical advice to help the state decide between two smart meters. The team analyzed the supply chain threat, focusing mostly on the hardware. They assessed risk of the components, both in their present state and as they age. "We also did thinking-cap studies, brainstorming how you might exploit vulnerabilities to attack Vermont's electricity grid," Noel says.

The BlackBerry pilot sought to quantify the threat of using the device from a supply chain perspective. As in the smart meter pilot, the team analyzed the BlackBerry hardware, looking at how the hardware is used, deployed, and tracked, among other functions. A second aspect of the study looked at how one would insure the integrity of a BlackBerry over time.

While Sandia has frequently provided technical advice to policymakers, the supply chain risk management project carries a deeper level of involvement than is typical. "We do play this traditional role because Sandia is a neutral entity with deep technical expertise and the ability to work within the federal government," Noel says. "Some aspects of this project, however, are stretching our workforce. We're gaining more understanding of how to advise policy and more exposure to a different notion of risk."

For the team working on the supply chain management risk project, it's an opportunity to combine creativity with technical research. Noel says the pilot studies were very well received and expects that Sandia will continue to support the router and BlackBerry supply chain risk management project.

Navajo Nation delegation visits Sandia/California

COMBUSTION RESEARCH — Mark Musculus (8362) describes high-speed imaging of high-efficiency, low-temperature engine combustion to representatives from the Navajo Nation. The group toured the Combustion Research Facility as part of their visit to Sandia.

Sandia/California VP Rick Stulen (8000) hosted Navajo Nation President Ben Shelly, First Lady Martha Shelly, and the Navajo Nation Energy Advisory Committee on July 28. The Navajo Nation is seeking input from Sandia and other DOE laboratories in forming its comprehensive energy plan, particularly in the areas of clean coal, carbon capture and sequestration, the water-energy nexus, and wind, solar, and geothermal energy.

Photos by Randy Wong

NAVAJO NATION President Ben Shelly, center, California site VP Rick Stulen, seated third from left, and members of the Navajo Nation delegation pause for a photo during a tour of the site.

WATCH OUT! A properly helmeted bicyclist tries to avoid a furry member of the workforce.

IN JULY, Sandia and Lawrence Livermore National Laboratory kicked off a monthly farmer's market in the General Access Area.

SECURITY OFFICER Tate Taylor (8511) stops for a quick chat with Melissa Patterson (8360) in the lobby of the Combustion Research Facility (CRF). With the new General Access Area, visitors to the CRF can go directly here to register and bypass the badge office.

A *GOLDEN* STATE OF MIND

Photos by Dino Vournas

In 1956, Sandia – the nation's largest and most diverse national laboratory – established a second campus in Livermore, Calif., to work in partnership with its Albuquerque campus in delivering science-based technologies that support national security.

Fifty-five years later, Sandia/California continues to provide crucial nuclear weapons capabilities to our sister laboratory, Lawrence Livermore National Laboratory, which happens to sit right across the street. More recently, energy has emerged as another critical mission area, with an emphasis on transportation. To fulfill our broader national security mission, which includes a strong commitment to homeland security, we cultivate multiple capabilities in biosciences, cyber security, materials science, engineering, and systems analysis.

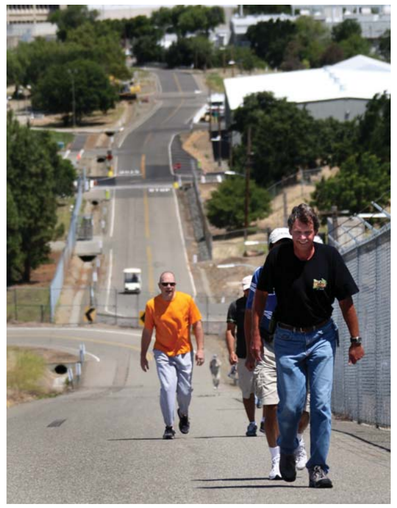
Situated at the edge of the San Francisco Bay Area, Sandia/California enjoys close proximity to first-tier universities, Silicon Valley companies, other cutting-edge research laboratories and facilities, and a wide variety of cultural and recreational opportunities. And, as you can plainly see from several photos on these pages, Sandia/California is blessed with abundant sunshine, nearby rolling hills, and beautiful landscapes.

As one of Livermore's largest employers, Sandia/California has a workforce of more than 1,000 people with robust postdoc and internship programs. Primary sponsors for our work include DOE, DoD, and the US Department of Homeland Security.

We think you'll enjoy this photo spread by photographer Dino Vournas, who captures some of the flavor and character of our site. We hope to see you here sometime soon!

SEVERAL YOUNG SANDIANS head out after picking up snacks at the café inside the Distributed Information Systems Laboratory to enjoy lunch in the sun.

THIS PANORAMIC VIEW depicts the Sandia/California site in all its glory.



WHO NEEDS THE STAIRMASTER? Exercise buffs head out to "the hill" for their lunchtime workout.

LUNCHTIME! When it's time to eat, workers in the Micro and Nano Technology Laboratory head outside to the courtyard tables.

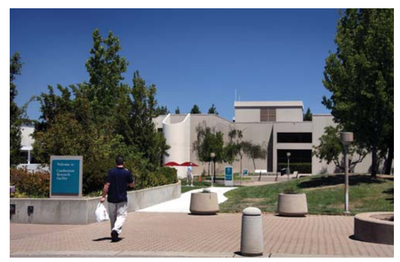
ART PONTAU (8360), Daniel Dedrick (8367), and Tom Settersten (8353) have an impromptu discussion at the CRF.

BIKERS AND CARS share the road at the main East Avenue checkpoint for both Sandia and Lawrence Livermore National Laboratory.

AH, YES, SUMMERTIME at Sandia/Livermore. Two health-conscious lab staffers take a stroll on a typically sunny California day. In the background is Bldg. 911, Sandia/California's main visitor's building.

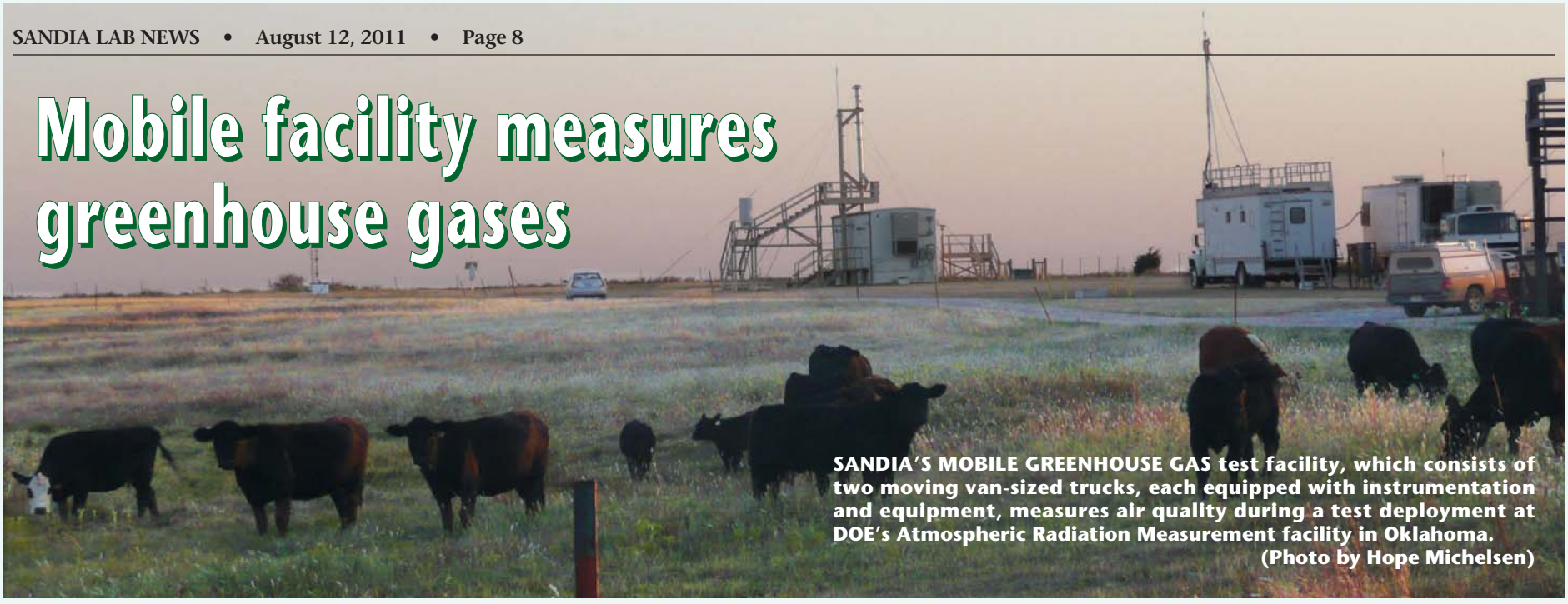
A MEMBER of the Sandia workforce, standing on the small bridge that links Micro and Nano Technologies Laboratory to other portions of the site, looks eastward out onto the arroyo.

SANDIA/CALIFORNIA'S newest addition, the Combustion Research Computation and Visualization building, is a popular place to hold meetings, with state-of-the art equipment and the flexibility of being in the General Access Area.



THE WORLD-RENOWNED Combustion Research Facility. The newest addition to the CRF complex, the Combustion Research Computation and Visualization building, is to the left but obscured here by the trees.

Mobile facility measures greenhouse gases



SANDIA'S MOBILE GREENHOUSE GAS test facility, which consists of two moving van-sized trucks, each equipped with instrumentation and equipment, measures air quality during a test deployment at DOE's Atmospheric Radiation Measurement facility in Oklahoma. (Photo by Hope Michelsen)

By Mike Janes

When funding became available for the NNSA labs to develop climate-change solutions, a number of researchers at Sandia put their collective heads together and agreed that a mobile facility — one that could be transported to various locations on an as-needed basis — would be a timely and useful contribution.

So that's what they built.

"What we proposed to do was build a mobile facility that would measure greenhouse gases and other species associated with those gases so they could be traced and identified," says Hope Michelsen (8353), a combustion and atmospheric chemist and one of the lead researchers on the project.

In addition to pinpointing the chemicals' location information, the idea behind the mobile facility is to learn whether the gases are biogenic (coming from plant sources) or anthropogenic (coming from man-made sources). This is important when officials look at ways to mitigate emission impacts in their communities, regions, states, or even nations.

"Elected officials who have enacted new policies to help reduce unwanted greenhouse gas emissions could conceivably find a mobile facility to be of great use," Hope says. "To figure out whether emissions reduction policies are effective, we need a way to measure emissions by emissions sector, such as power generation or transportation. We currently don't have the tools in place to do these types of measurements, so we hope our idea can be part of the solution."

The mobile system, which has already been deployed once to the Atmospheric Radiation Measurement (ARM) facility in Oklahoma, consists of two moving van-sized trucks, each equipped with instrumentation and equipment. Included are instruments that measure greenhouse gases, such as carbon dioxide (CO_2) and methane (CH_4), and species co-emitted with greenhouse gases, such as sulfur dioxide (SO_2), nitrogen oxide (NOx), carbon monoxide (CO), ozone (O_3), and other traditional pollutants.

While the instruments are all commercially available, another current project funded internally at Sandia aims to build an instrument that measures black carbon soot, a devastating warming agent formed through the incomplete combustion of fossil fuels, biofuels, and biomass.

Distinguishing emission sources

Atop each truck sits an antennae-like mast that sucks in air, sends it down into the truck, and distributes it to the various instruments, including a mass spectrometer that sorts out hydrocarbons and helps to distinguish between emission sources, which can range from traffic to pine trees.

A piece of equipment provided by Lawrence Livermore National Laboratory (LLNL) captures samples in flasks for analysis at LLNL's Center for Accelerator Mass Spectrometry to measure the radiocarbon (^{14}C) fractionation of CO_2 (^{14}C is a radioactive isotope of carbon).

Because ^{14}C is severely depleted in fossil fuels, it is a powerful indicator of man-made CO_2 sources. Some of these samples were also sent to the National Oceanic and Atmospheric Administration and to the University of California, Davis for further trace gas and isotopic analysis.

The ARM location in Oklahoma, says researcher Ray Bambha (8128), was selected because of its solid history as a climate research site. Ray served as the principal investigator for the field experiment, alongside several other Sandians serving in key roles. Collaborators from both LLNL and Los Alamos National Laboratory joined the Sandia team for portions of the Oklahoma deployment.

THE AIR UP THERE — Fred Helsel (6913), Paul Schrader (8353), and Ray Bambha (8128) work atop one of the mobile facilities designed to measure greenhouse gases and other species so that they can be traced and identified. (Photo by Hope Michelsen)

'Uncertainty quantification' capability

The pilot deployment, Ray says, was successful in that the system collected large quantities of data, which is still being analyzed. It allowed the team to test instruments that hadn't been used previously, and it helped them to understand the atmospheric community's need for an "uncertainty quantification" capability — a method of assigning a confidence level to an estimate — and tracer measurements, which provide a more effective method for identifying the source of certain emissions.

Hope says Sandia is building a team of researchers that can take the next step with the system and begin to use wind information and inverse modeling to more accurately identify emission sources.

In the short-term, Hope says, program development efforts are well under way in hopes of securing follow-on funding and other test deployments. The long-term vision for the program calls for a full network of mobile facilities that could be deployed strategically in select regions, states, or cities to enable the capturing of a broad spectrum of emissions and related information.

Assemblymember Joan Buchanan visits California lab

WHEN ASSEMBLYMEMBER Joan Buchanan visited the California site, Div. 8000 VP Rick Stulen provided her with an update on the Livermore Valley Open Campus (LVOC), the Small Business Assistance Program, and the new Combustion Research Computation and Visualization (CRCV) facility (which she toured). She also met with researchers with the Center for Cyber Defenders (CCD). Buchanan was elected to the State Assembly in November 2008 from the 15th Assembly District, which includes portions of Alameda, Contra Costa, Sacramento, and San Joaquin counties. A member of the Assembly Budget Committee, Buchanan chairs the budget subcommittee on State Administration and Information Technology. She also chairs the Select Committee on Government Efficiency, Technology, and Innovation, among other roles. In the photo above, Rick and Buchanan are joined by Center 8300 Director Bob Carling in a discussion about the capabilities of the CRCV. (Photo by Randy Wong)

Lessons

(Continued from page 12)

John brought home other observations from his time in New Zealand that he has shared in several presentations around the site. "Naturally, everyone's first thought is with their family's safety. But not just immediately after the event, it goes on much longer," he explains. "Schools were closed, the city's sewer system was out, and there were frequent aftershocks. So people just left the area. We need to realize here that if we have such an event at our site, a good part of our population will leave and won't be able to respond to work for some time."

THE PYNE GOULD BUILDING destroyed by the 2011 earthquake that struck the vicinity of Christchurch, New Zealand. Several people died when the five-story building collapsed.
(Photo by Gabriel, Wikimedia Commons)

Many Sandians already work remotely, but the network is not designed for sustained telework by over half the workplace. "We saw this with the cold snap in Albuquerque," says Don Charlesworth (8511), manager of security operations for the California site. "The network reached capacity and this site had to route traffic."

Christchurch is the financial center of New Zealand, so it was critical to the country's economy to get major businesses up and running again. "Fortunately, most companies have an offshore presence, so they were able to transfer the work to another location," says John. "We have a mindset as Sandians that by golly we can overcome anything and we can do anything — which is true — but in an emergency response situation and emotions are running really high, how true is that? Have we really thought about the need for New Mexico to be able to operate the site — I mean really operate the site, not just keeping the lights turned on, but programmatically?"

THIS HOME in the Redcliffs area of Christchurch, New Zealand, was destroyed when the cliff behind the house collapsed, raining boulders and debris down on the houses below.
(Photo by Schwede66, Wikimedia Commons)

The Sandia/California Security, Safety, Health and Environment Action Committee (SSHEAC) began examining this issue, business continuity of operations, more than a year ago. A draft of the plan is expected in the fall. John's experience in New Zealand served to underscore how critical this planning is.

"Seismic preparedness is something I talk a lot about at our California site," says Div. 8000 VP Rick Stulen. "Having experienced the big Greenville Fault quake in 1980 that temporarily closed parts of Sandia, I know firsthand how powerful even a magnitude-6.0 quake can be and am reminded how ill-prepared I was at the time. We are much better situated today but we still need to challenge our readiness, individually and as a laboratory, against scenarios larger than 6.0. At any point during the work day we should know what to do if a big one hits and always keep our work spaces free of potential falling or blocking hazards."

Don adds that John's experience is also a reminder to consider emotional factors in emergency planning. "It hasn't been at the forefront for me," says Tommy Clark (8511). "We tend to focus on the mechanics, like getting people safely out of buildings. We will make this an element of future drills to keep them as realistic as possible."

Before September, New Zealand had gone more than 70 years without a major quake. It hasn't been that long for the San Francisco Bay Area — Loma Prieta was 22 years ago — but Don thinks complacency has set in. "The more time that goes by, the more distant that experience of dealing with devastation becomes," Don says. "The earthquakes in New Zealand and Japan, along with that country's tsunami, serve as reminders that really bad things can happen."

John doesn't regret the timing of his trip to New Zealand and says the experience won't dissuade him from visiting the country again. "It's made me rethink how my family would respond to a major earthquake," he says. "My wife and I worked out a comprehensive communications plan with our daughters and we've tackled tough questions, like what would we do if our house was demolished?"

Memories

(Continued from page 12)

enced more severe shaking because of his proximity.

Pamala Vela (8231) was working at the fourth-floor switchboard at a law office in Palo Alto, Calif. When the office began to sway, she was on the phone with a man in Denver. "I told him we were having a little quake, but not to worry, we don't get big ones very often," she explains. "The building swayed for another 10 seconds and then it felt as if someone had slammed their fist into the side of the building. It began to violently shift back and forth."

She put the man on hold and took cover. "Desk drawers were slamming in and out, law books were literally flying off the shelf. From beneath my desk I watched with a co-worker as pictures flew off the wall and ceiling tiles became lethal projectiles," Pamala recalls. "There was screaming and it felt like the building was coming down. In emergency-adrenaline-brain-overload time, it felt like the shaking went on for three to four minutes."

When the shaking stopped, she realized the man in Denver was still on hold. "I knew the phone connection would not last long, so I quickly gave him my parents' phone number and asked him to call them collect and let them know I was okay," says Pamala. "Both of my parents, who lived in Arkansas, had heart conditions and I was worried they'd fear the worst when they heard about the earthquake."

Once Pamala returned to her home — a 20-mile drive that took her four hours that day — she found her house messy but still standing. She had six days' worth of emergency food and water and an extensive medical kit, which she used to help her elderly neighbors take care of scrapes they suffered during the earthquake. She also shared some of her ready-to-eat canned food. Her water was still running, but not trusting that it was clean, she drank the stockpiled emergency water. Pamala's electricity was out for three days.

Since the Loma Prieta earthquake 22 years ago, she's gotten a bigger medical kit and keeps a six-day emergency kit at home plus a travel kit in her car. "I'm prepared to walk to my home in Tracy, if necessary," she says. "So I've got shoes, spare clothes, food, water, and a basic first aid kit."

THE INTERSTATE 880 "Cypress Structure" collapsed in the Loma Prieta earthquake on Oct.17, 1989.
(Photo by Dino Vournas)

Jill Micheau (9529) was working on the 15th floor of a building in San Francisco's financial district. "The building really rocked and rolled. People ducked under desks and into doorways, but it was over before any of us had a chance to really think about what was happening," she says. "It was very frightening. After it was over we saw that a huge Xerox copier had literally walked across the room."

From the building's windows, Jill and her colleagues had a 360-degree view of San Francisco and the surrounding area, including the Bay Bridge and fires burning in San Francisco's marina district. They had plenty of time to observe, as they were not allowed to leave the building for about four hours.

Communication — or lack thereof — was the scariest part of the aftermath, says Jill. She was concerned about her one-year-old son in Berkeley, her then-husband who would have been on the Bay Bridge when the quake struck (fortuitously, he left work a few minutes early that day), and friends in the South Bay. "Our vice president had a cell phone. It was about the size and weight of a brick, but we were able to call our families," says Jill.

Don Charlesworth (8511) had the unusual experience of having just departed on a flight for a business trip from the Oakland airport five minutes before Loma Prieta struck. When his flight landed in Albuquerque, the passengers were met by media. "They started asking us about the earthquake — we were from the Bay Area — but we had no idea that anything had happened," he recalls.

Behind the lens

A sports story becomes life-and-death news

On Oct. 17, 1989, Sandia photographer Dino Vournas was covering the A's-Giants World Series for the *Hayward Daily Review*. "It was the biggest sporting event ever in the Bay Area, and in an instant became a life-and-death story, the biggest news story I've ever covered," he recalls. "I immediately switched into a different mode as a photojournalist. We were all fighting fear — we were hearing reports of the Bay Bridge and Cypress freeway collapses and fires in the marina, but this was history, a story that had to be told."

Dino was climbing over the VIP boxes at Candlestick Park to get to his spot when the earthquake struck. The first jolt sent him into the lap of Blue Jays manager Cito Gaston. "A remarkable thing happened immediately after the earthquake. The baseball players became regular people, no longer stars. Everyone was scared and thinking of their families and friends. When the call came to evacuate Candlestick, we all walked out together," he says.

He spent the next few days covering rescue efforts at the Cypress freeway. "It was very emotional being there with people who were awaiting news of loved ones," Dino says. "I often think back on the good fortune that the A's and Giants were playing in the World Series at 5 p.m. that day. On a normal day, that freeway would have been bumper to bumper at that time and many more lives would have been lost. I crossed that freeway six or seven times a week."

Mileposts

New Mexico *photos by Michelle Fleming*


Tom Baca
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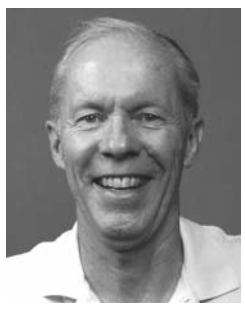
Bud Burns
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Errold Duroseau
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Barry Schwartz
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Tom Ashwill
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Bryon Cloer
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Bob Cutler
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Mark Hedemann
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Michael Johnson
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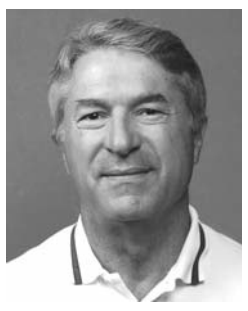
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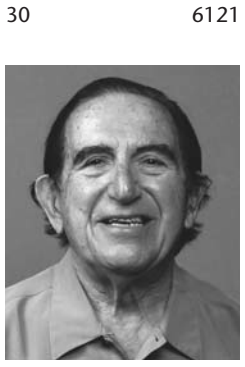
Michael Mazarakis
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Duane Schneider
30 1132


Steven Yearout
30 5733


Kim Mitchiner
25 6612


Garth Reese
25 1542


Berta Armijo-Chavez
20 3521


Julie Bouchard
20 6923


Teresa Cajete
20 10248

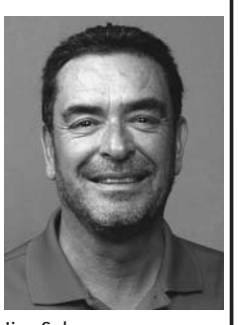

Patti Sanchez
20 233


Daniel Schell
20 3520


John McGlinchey
15 5543


Heidi Smartt
15 6832

Recent Retirees


Jim Salas
38 2553


Pam Walker
31 2714

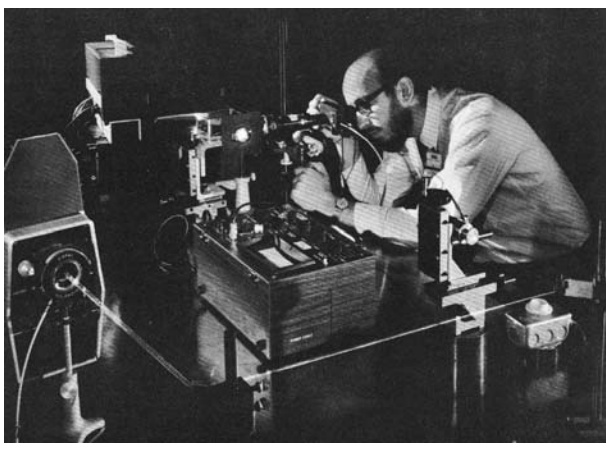
California

The content here is taken directly from back issues of the *Lab News*.

50 years ago . . . The Salton Sea Test Base in southern California has been 'phased out' by Sandia Corporation. Salton Sea has been used for drop testing of weapon shapes, as an emergency landing area for seaplanes, for a movie set, and for salt mining operations. Now sand drifts against the instrumentation tower. In 1946, after the "Crossroads" test in the Pacific, the Field Testing organization of Sandia Laboratory (then operated by the University of California) needed a site to make drop tests where the bomb would impact at sea level. An area near Los Lunas, N.M., had been used for such tests but the mile-high altitude was undesirable. Salton Sea was desirable. The weather was good and the government already owned the land. Salton Sea Test Base, as it was designated, covered over 81 sq. miles, nearly two-thirds of it underwater. In 1954, operations at Salton Sea began to phase out. On July 1, 1961, Salton Sea Test Site was placed on a standby basis, deserted except for a handful of employees to provide maintenance and property protection.


TELEMETERING, RADAR, and microwave antennas decorated the Salton Sea instrument laboratory. This was one of the original Navy buildings when the installation was taken over by Sandia Corporation.

40 years ago . . . Two techniques — holograms and scattered light photoelasticity — are being used by Experimental Mechanics Division 8122 to observe surface deflections and to analyze stress in small engineering components. Measurements obtained experimentally in the Photomechanics Lab are applied to theoretical calculations to give design engineers meaningful data on the special materials and geometric shapes they use. Scattered light photoelasticity is currently one of the few promising and effective techniques of obtaining a complete three-dimensional stress analysis.


STRESS ANALYSIS OF A MATERIAL is made by Wil Jorgenson of Experimental Mechanics Division 8122 using scattered light photoelasticity technique.

30 years ago . . . Fundamental studies of wood pyrolysis/combustion have been completed at Sandia Livermore working with the Weyerhaeuser Company of Tacoma, Wash. Working cooperatively with private industry to conduct basic research that may lead to less dependence on oil, the experiment involved making measurements of the burning characteristics of wood samples. Weyerhaeuser researcher Grant Karsner collected fundamental information on the residence times required for particle ignition for a variety of reaction conditions. As a result of his experiments at Sandia he is now able to calculate how many milliseconds it takes for specific fuels to ignite under controlled conditions. Included in the study are a variety of fuels: coal, peat, char, and wood.


Grant Karsner of Weyerhaeuser, left and Bill McLean (8521) examine pulverized wood samples used in an

20 years ago . . . Under one roof in Experimental Mechanics Div. 8246 are mechanical testing facilities that measure force in grams or kilotons, computer-controlled facilities that do multiaxial materials testing, test systems that span a dozen decades of strain rate, and a full complement of laser diagnostics — and these are just samples DOE and qualified industrial customers can utilize Sandia's mechanical testing capabilities to avoid the expense of purchasing their own capital equipment and the delays involved with having to train their own staffs.

Farmer's market

In July, Sandia and Lawrence Livermore National Laboratory kicked off a monthly farmer's market in the General Access Area.

Sandia's influence in Golden State highlighted in first-ever California economic impact report

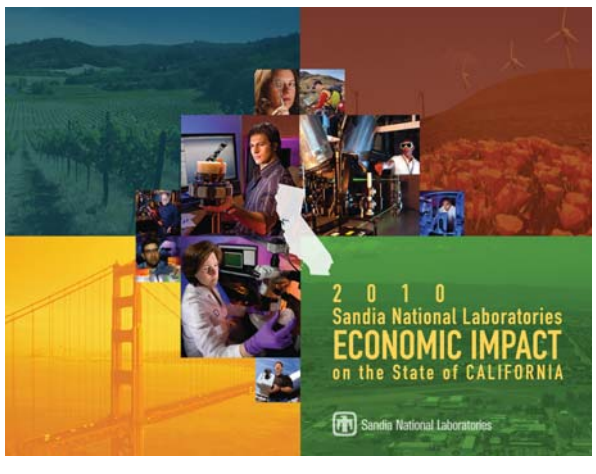
By Mike Janes

Sandia has issued its first-ever *Economic Impact on the State of California* report. The brochure covers fiscal year 2010.

The report outlines Sandia's expenditures in the state of California, including small business contracted-related payments, P-Card purchases, labor, and taxes. It also examines Sandia partnerships with California universities and other schools, community involvement impacting the state in a positive way, and expectations surrounding the Livermore Valley Open Campus (LVOC).

"The state of California represents unrealized potential as Sandia's partner in contributing to Laboratory missions," says Denise Koker (8520), senior manager of human resources and business operations for Division 8000. "The state — especially the Bay Area — is recognized as a global leader in energy innovation and emissions control, as well as a center of high tech R&D and industry.

"With two national laboratories serving as an instigator for regional economic development, the Livermore Valley has the potential to be a new high tech economic cluster," says Denise. "Elected officials in the region and around the state, as well as other external stakeholders of ours, are sure to take notice of the data found in this report."



"Sandia is a significant economic engine for the state of California," says Karen Scott (0162), manager of government relations at Sandia/California. "Between employee compensation, purchases, contracts, and state corporate taxes, Sandia directly injects $319 million into the California economy."

In addition to having led this report's development, Catherine Dawson (8533) is working with the Center for Economic Development (CED) at California State University, Chico, to quantify the "re-spending" or indirect impact of Sandia's activities in California. Indirect impacts of Sandia's spending are responsible for an additional $25 million in revenue to California's state government and $635 million in additional revenue to other businesses and organizations in the state.

The *Economic Impact on the State of California* brochure is available via the Sandia/California public relations office or at the Lab's online news room at http://tinyurl.com/3gvtdtk. It was sponsored by Don Devoti (10222), manager of Sandia's small business utilization department.

SEISMIC SHIFT

Lessons from the New Zealand earthquake

By Patti Koning

When John Garcia (8510) traveled halfway around the world to New Zealand in February, he was looking forward to catching up with old friends, visiting the country's beautiful beaches, and enjoying fine cuisine. He got all of that — and a surprise magnitude-6.3 earthquake.

"It was quite an experience, one that I did not expect," says John. "My wife and I went to New Zealand for rest and relaxation and to reconnect with friends — which we still did, despite the situation. You just never know what is going to happen."

John, his wife, Gisele, and his mother, Marge, arrived in New Zealand on Feb 18. The trip went as planned for the first four days. They visited family friends in Auckland for a few days and then drove to northern New Zealand to visit other family friends.

Feb. 22 felt like any other day to the Garcias. "We stopped at a restaurant on the way back to Auckland and my wife thought she felt something, but we didn't think much of it," he says. "I had turned off my personal cell phone, so we were completely disconnected. It was quite the return to Auckland, however."

At 12:51 p.m. local time, the magnitude-6.3 earthquake struck Christchurch, the country's second largest city. The quake killed more than 180 people, injured many more, and caused massive damage in the area. Two large office towers, the Pyne Gould building and the Canterbury Television headquarters, collapsed almost immediately and the spire of the landmark Christchurch Cathedral crashed down in an aftershock.

Auckland is nearly 500 miles northwest of Christchurch, so there was little direct impact from the quake. The Garcias' friends, however, had parents and siblings in Christchurch, some of whom they had been unable to contact. Over the course of the chaotic day, they were finally able to reach all their loved ones.

The Garcias had plans to visit those friends in Wellington who had family members affected by the quake in Christchurch. "We considered not going because our friends, Leslie and Brent, both work for the New Zealand government and were very involved in the emergency response," says John. They went to Wellington as planned and as a result, were able to see the recovery effort through Leslie and Brent's experiences.

THE CALM BEFORE — John Garcia and his wife, Gisele, on right, with a New Zealand friend at Frog Beach before the earthquake. (Photo by Trudy Caisley)

In September 2010, New Zealand experienced a magnitude-7.0 earthquake, which caused billions of dollars in damages but no deaths. The February 2011 quake was unusually shallow, occurring at a depth of about three miles, with an epicenter just three miles from Christchurch, compared to 30 miles in September.

"That September earthquake spurred a re-examination of building codes and development of emergency response procedures," says John. "When the February quake happened, it was fresh in people's minds. They felt like they'd dodged a bullet, so when another, much more devastating quake hit, people really panicked."

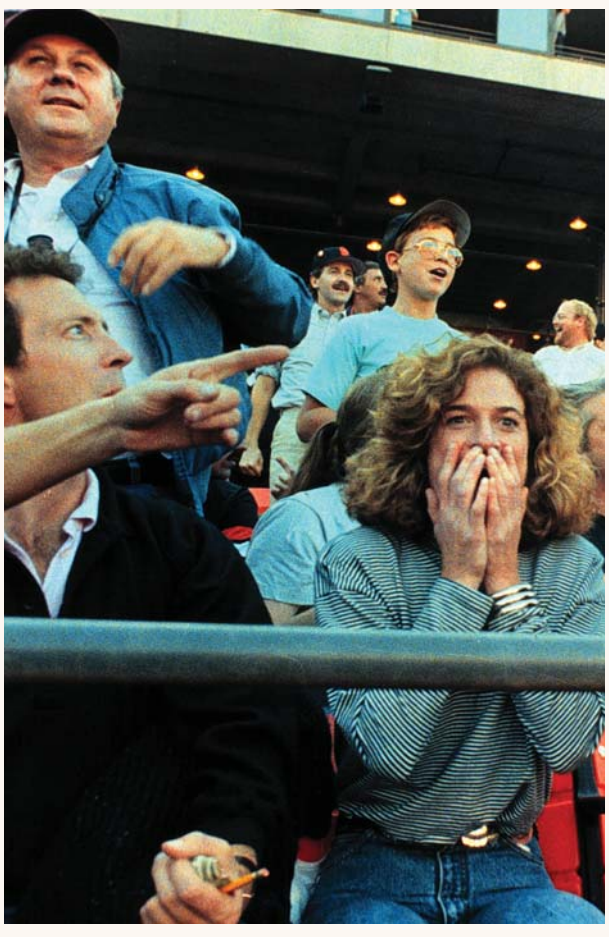
The Garcias' friends and family back in the US panicked as well and John's cell phone was inundated with calls within a few minutes of the quake — calls he couldn't retrieve until much later, but he was able to text message his two daughters.

Texts, which require less bandwidth than a phone call, can get through when phone calls can't. "How many people of my generation or older are texting? I only know how because when my daughters were teens it was the only way I could communicate with them," says John. "Fortunately, we set up texting before the trip because it was much cheaper than calling from New Zealand."

Facebook also was a critical resource. John quickly posted updates on his Facebook page to let a wider circle of family and friends know he was ok. He also shared information about relief efforts and how people could help. "In an emergency, social media and cell phone based communication becomes primary. It's not just entertainment," he says. "Anyone who isn't on Facebook for social reasons should consider it as part of their emergency plan."

Social media has become a crucial component of emergency response and any wide-scale communications. The Los Angeles Police Department (LAPD) asked celebrities with large Twitter followings to help spread the word about the closure of a 10-mile stretch of the 405 freeway over the weekend of July 15, an event jokingly referred to as "Carmageddon." According to the *Los Angeles Times*, the LAPD contacted representatives for Lady Gaga, Ashton Kutcher, Demi Moore, and Kim Kardashian, who collectively have more than 30 million Twitter followers.

(Continued on page 9)



EMOTIONS RAN from fear to shocked astonishment moments after the Loma Prieta Earthquake shook Candlestick Park during game 3 of the 1989 World Series. (Photo by Dino Vournas)

Earthquake memories

By Patti Koning • Photos by Dino Vournas

Livermore was last rocked by an earthquake 22 years ago. On October 17, 1989, a magnitude-6.9 earthquake, known as the Loma Prieta earthquake, struck at 5:04 p.m., centered in the Santa Cruz Mountains. Buildings collapsed in Santa Cruz; a landfill in San Francisco's Marina district suffered liquefaction, and a natural gas main ruptured, causing a major fire; a section of the upper deck of the Bay Bridge collapsed onto the deck below; and the two-level Cypress viaduct of Interstate 880 in Oakland collapsed, killing 42 people.

While Livermore was far enough from the epicenter to escape serious damage, many Sandians were in other, more affected parts of the Bay Area that day. Kevin Krenz (8135) was feeling very lucky that afternoon because a friend had scored field-level seats to game four of the World Series at Candlestick Park. About 15 minutes after they arrived at the stadium, something strange happened.

"At first we thought it was people on the upper decks stomping their feet," he says. "Then I looked behind home plate and saw the wave hit. You could see the concrete moving in about five or six big oscillations. There was dead silence, and then everyone cheered. I guess it was relief that we were all okay."

Kevin says he was more frightened by a 1987 earthquake, which had an epicenter under Mount Diablo, about 10 miles from his home. While that earthquake was of much smaller magnitude, about 4.1, he experi-

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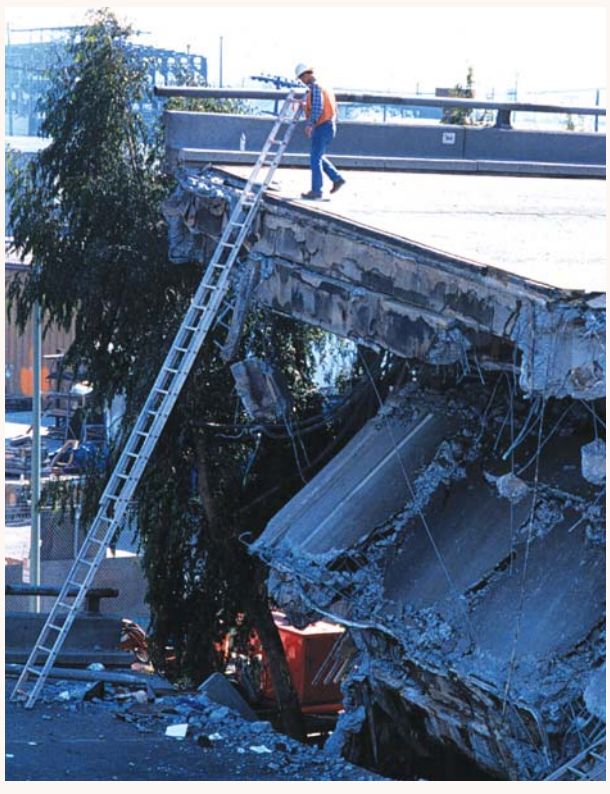

THE INTERSTATE 880 "Cypress Structure" collapsed in the Loma Prieta earthquake on Oct.17, 1989. CalTrans workers aided in the rescue attempts for trapped motorists. (Photo by Dino Vournas)