New initiative will bolster infrastructure for hydrogen vehicles

**Livermore Valley Open Campus will facilitate successful operation of CIRI**

*By Mike Janes*

The broad public and government interest in renewable energy and the hope for a zero-emission transportation future seem to be at an all-time high. So what is the remaining hurdle to overcome before we see widespread adoption of clean, hydrogen-powered vehicles on the road?

In a word: infrastructure. For hydrogen-based vehicles, very little infrastructure currently exists. But that could change soon, and Sandia, center for Infrastructure Research and Innovation (CIRI) on the Livermore Valley Open Campus (LVOC) hopes to contribute in a big way.

Daniel Dedrick (8367), the Labs’ hydrogen program manager, calls CIRI a “collaboration facility” modeled on the success of the Combustion Research Facility (CRF). For years, the CRF has played a critical role in partnering with industry to provide a science base for fine-tuning the internal combustion engine and making it cleaner and more efficient.

“CIRI is a partnership-based RD&D facility focused on hydrogen infrastructure,” Daniel says. “More specifically, it will be a coordination of critical materials, science, and engineering research capabilities at Sandia that are needed to improve performance and reduce costs associated with hydrogen infrastructure.

CIRI will incorporate new resources, including a full-scale test facility where equipment manufacturers can test their hardware, and existing capabilities such as a material mechanics lab that analyzes, characterizes, and predicts the behavior of various materials. It will also include a testbed refueling station where industry and research partners can run experiments to better understand refueling dynamics.

CIRI’s partners, Daniel says, will include industry members up and down the supply chain and include companies who sell gases and chemicals, as well as those companies who manufacture important components like compressors, tanks, and tubing. Testing and optimizing those components in a systems environment — another feature in the works for CIRI — will be critical in developing hydrogen refueling stations and making them more economically and technically feasible for consumers, fuel providers, and station operators.

Industry, of course, will be key to CIRI’s success, and Daniel points out that the nearby CRF already has a long history of partnerships with all of the US automakers. He hints that “significant support” for CIRI has already been assured from a number of critical companies.

The long-term vision for CIRI also includes research of vehicle systems integration with the electrical grid to understanding how hydrogen can help address issues associated with renewables integration, energy storage, and distributed generation.

**Hydrogen on the upswing**

Since the introduction more than 100 years ago of the modern, now-ubiquitous internal combustion engine that operates on gasoline, the nation has developed, honed, and successfully deployed tens of thousands of domestically produced, zero-emission vehicles.

In the late 1990s, talk of hydrogen-powered vehicles went away — tens to hundreds of kilometers — you need a really big detector. (Continued on page 3)

**Sandia plays key role in Long-Range Stand-off warhead**

*By Mike Janes*

Sndia, Livermore Valley Open Campus

Lee Drumman, Bryn Miyahara, and Andrew Van Biargan (all 8248) assemble a 3-D, model used to illustrate high-level LRSD concepts, in the Test Assembly Group’s High Bay.

(Continued on page 8)
That's that

Note: This guest column was written for the special California edition of the Sandia Lab News by Div. 4800 VP Steve Rottler.

When I was asked to pen this issue's "That's That" column with a theme of diversity and inclusion, I was delighted. DI is clearly an important initiative for Division 8000 and, indeed, for the entire laboratory. So I'm pleased to offer some thoughts and anecdotes that I hope will give Lab News readers a sense of my personal commitment to these issues.

My earliest understanding of diversity and inclusion came courtesy of two wonderful parents. They never called Mom and Dad using the words “diversity” and “inclusion.” Rather, they taught these concepts through the values and life lessons they shared with me.

As I started elementary school, I recall Mom explaining I would meet children who did not look or talk like I did, and stressing the importance of accepting them as individuals, rather than judging them by the color of their skin, their gender, or their religious beliefs. I recall the experience of living overseas for three years, and finding myself, almost overnight, in a place with a language I could not speak or translate, with customs I did not understand, and where I was looked upon as someone strange and different.

I recall living in a small northeastern Texas town in the early and mid-1970s. The public schools had been racially integrated for three years, but the attitudes of many in the community remained such as they had been for the better part of a century. I experienced, in ways that were often physically painful, the challenges of trying to "straddle the line" in a racially divided community. And I recall the emotional pain of watching one of my closest friends reject forevermore another very close friend because the other friend could no longer live comfortably with us not knowing he was gay. These and other similar experiences affected me profoundly, and formed the foundation upon which I built my views about diversity and inclusion as an adult and a professional.

Three years ago, I was introduced to the concept of unconscious privilege—a special advantage enjoyed by an individual solely by virtue of some characteristic, such as skin color, gender, or religious belief. I benefit from such privileges because I am a white male. I cannot "give back" these privileges, and I receive them ever so slowly or sought nor intentionally accepted them. I have learned to embrace the uncomfortable ambiguities one experiences when you are a beneficiary of unconscious privilege. These ambiguities often appear as paradoxes.

Two such paradoxes that have deep meaning for me are “it is not my fault, but I am responsible,” and “I am blind to our differences, but will also be conscious of them.” I am now able accept both sides of these paradoxes while not negating either side. This experience has opened my eyes to new, more meaningful, dimensions of diversity and inclusion, and helped me better understand my responsibility as a leader.

A commitment to diversity and inclusion requires a concomitant commitment to lifelong learning—learning about yourself and others, constantly challenging the very beliefs that you hold, and biases you hold. At the workplace, and in society overall, I have learned to think of diversity and inclusion, and I prefer to think of it as a humanist concept. To feel and be included is a basic human need, and we acknowledge and honor our humanity when we dedicate ourselves to the achievement of greater diversity and inclusion, both at the workplace, and in society overall.

Thank you for reading. I hope you enjoy our annual "all-California" edition of the Sandia Lab News.

- Steve Rottler, Div. 8000 VP

CRF Research shows wide appeal

By Holly Larsen

Adding to the numerous citings of Combustion Research Facility (CRF) papers in the past, three new examples confirm the value that others place on the laboratory’s work.

While visiting the website of the Proceedings of the Combustion Institute (http://www.journals.elsevier.com/proceedings-of-the-combustion-institute/), a biennial publication at the forefront of combustion science, San- dia senior scientist John Dec (8830) of the Transporta- tion Energy Center discovered that a paper he had written in 2008 is the most cited of all the papers in the Proceedings. Since publication, “Examining Ignition Efficiency — Understanding the In-Cylinder Processes” has been cited 128 times, most recently in 2013 articles in Combustion Science and Flame, the journal of the Combustion Institute. For perspective, the Pro- ceedings’ two most cited papers have been cited 81 and 80 times.

John has a simple explanation for the article’s wide appeal.

“It’s a review article that gives a good summary of work in this area that probably isn’t available else- where,” he says. What is somewhat surprising is the paper’s continued growth over the years. “Citing a single point, an updated paper will appear, and this one will drop out of sight.”

Patti Koning and Mike Jares (both 8521), seen here during a recent emergency response exercise at Sandia's Livermore, Calif., site, once again took over the helm of Sandia Lab News as guest editors for the 70th anniversary issue. Here is their perspective regarding the site’s research, people, and happenings.

(Photography by Randy Wong)
Motors and Honda Motor Co. are now partnering to notion that automakers remain bullish on hydrogen fuel cell vehicles. because fewer high-cost materials are necessary with compare favorably to electric battery vehicles, mainly "They understand the benefits of hydrogen fuel cell automotive industry has stayed the course, says Daniel. ernment investments, and competing technologies, the based fueling infrastructure. immature in the consumer environment and requires a limited, largely because the technology is relatively fuels of hydrogen fuel cell vehicles. Sandia became a member of H2USA this month.

Daniel and Sandia's transportation energy experts, along with their federal sponsors, understand the role that hydrogen fuel cell vehicles have continued to move the technology forward. Hydrogen fuel cell vehicles, Daniel asserts, compare favorably to electric battery vehicles, mainly because fewer high-cost materials are necessary with fuel cell vehicles.

Recent news reports would appear to confirm the notion that automakers remain bullish on hydrogen fuel cell vehicles. According to a July report from Bloomberg, General Motors and Honda Motor Co. are now partnering to bring hydrogen fuel cell vehicles into the marketplace.

In November, Toyota Motor Corp. is expected to unveil its own fuel cell vehicle, one that is expected to go on sale in 2015 for $50,000 and $60,000. For Honda, the decades wouldn't be possible without that network of fueling stations.

A fuel cell-based infrastructure, however, is limited, largely because the technology is relatively immature in the consumer environment and requires a different approach compared to the existing liquid-based fueling infrastructure. "They understand the benefits of hydrogen fuel cell vehicles and have continued to move the technology forward," Daniel says. "They understand the benefits of hydrogen fuel cell vehicles and have continued to move the technology forward."

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Data center modernization, consolidation will enable more efficient use of resources

By Mike Janes

Sandia’s California site prides itself on being innovative, connected, nimble, able to take on mission problems with the efficiency and pioneering spirit of the Silicon Valley neighbors.

That may all be true, but when it comes to the site’s essential computing infrastructure — and a facility to house it all — Division 8000 has been somewhat static and unable to do what it takes to maintain a world-class operation.

“We need to modernize the Sandia/California data center not only because it’s deteriorated, but more importantly to help us to build, adopt, and implement the core of the Labs’ external cloud,” says Steve Carpenter (8945), who manages the information systems and services group at the California site. A successful modernization effort, Steve says, will also provide the opportunity for consolidation of redundant services and applications corporate-wide, and will provide agility and on-demand elasticity.

The problem of “sprawl” of distributed resources, Steve says, is reflected in too-high costs, elevated energy consumption, and risk of IT-related security incidents or data loss. The benefits of successful modernization and consolidation, he says, include disaster recovery and business continuity, more effective maintenance planning and operations, and integrated services that help improve mission delivery.

Into the 21st century

So change is coming. For its part in a five-year, laboratory-wide data center consolidation (DCC) effort, the California site is aiming to complete a modernization and consolidation strategy that will bring the site’s data center well into the 21st century. Matt Schrager (8945) and Mike Kurtzer (8945-1) are leading the project for Division 8000.

“When people think about where their Sandia information and data are stored in the future,” adds Steve, “they won’t have to care about which one it is or where it’s located, it will simply be ‘the data center,’ consistent with how we think about the cloud services we’re all becoming accustomed to now.”

Before the site can effectively operate, it needs to modernize, the team asserts. So the first order of business has been the development and execution of a modernization plan.

The modernization study began with a needs assessment that sought to determine the site’s customer IT needs and requirements, both present and future, to fulfill mission and programmatic goals. Based on the study’s findings, several conceptual options for a modern data center were developed. The options include modernizing the existing data center (which currently resides in the basement of Bldg. 912), renovating an existing building, purchasing or leasing a modular/POD type structure, or raising a new building.

For years, says Mike, the California site’s main data center has experienced deterioration with infrastructure issues such as cooling and power. Consequently, upgrades to air handlers and air delivery, power distribution, flooring systems, and other hardware would be needed for the facility’s successful modernization.

Another key feature that has previously been missing in the Sandia/California data center is redundant power and cooling capabilities. Redundancy would ensure that the data center could still operate without interruption if a power source went down or if there was a mechanical failure in a cooling system unit. Cooling impacts can be avoided by ensuring a sufficient number of air handlers are available to support the environment in the event of a cooling unit failure, says Steve.

Currently, the majority of equipment in Sandia/California’s data center is powered by a single source. Most critical data centers, Matt says, have redundant power and cooling.

“Some of our most critical programs need power 24/7 no matter what. They simply can’t afford to have even a moment of down time,” Matt says. “They must have redundant and unlimited power supply from multiple sources to draw upon for failover.”

As part of the current study, Matt says this component of the project is largely being driven by DOE requirements, though Mike and Matt both say consolidation has been needed at the California site for years.

“They [DOE] want their facilities to reduce power consumed at all external data centers and servers that move and consolidate is a good way to leverage those areas for efficiency,” Mike says. “Power and cooling are the two biggest concern of electricity and thus the two areas where consolidation can have the most impact.” An important side benefit of the consolidation effort, Mike says, is that moving some server infrastructure into the primary data center may open up much-needed space for potential office space.

Even without DOE’s directive, Matt says, consolidation at Sandia/California has become a necessity.

“Some members of the workforce have developed their own storage, computational, or web servers and manage these themselves,” Matt says. The assumption, he says, was that there would be cost savings and improved efficiency, but the result has been an infrastructure spread throughout the site that’s been decidedly inefficient and difficult to manage.

Fortunately, Mike says, owners and administrators of these “rogue” servers have largely been understanding of the site’s consolidation needs and willing to consider relocation of their resources into the primary data center.

“Most of the people we interview are open to a shared, centralized data center,” says Matt. “It’s been a pleasant surprise, as we expected more resistance.”

Some programs will continue to require their own servers and resources, however. The site’s Emergency Operations Center has unique needs that can’t be met in a shared environment, and the same can be said for other special programs. Eventually, Mike and Matt hope that a shared — yet secured — environment can replace the vast majority of independent servers around the site.

Laboratories-wide benefits

Mike and Matt say that, although tangible benefits to the workforce are expected, the end result of the modernization/consolidation effort will be largely invisible if the work is done correctly. “It should be a seamless transition, though energy efficiencies, less noise, and more available space for other uses will certainly have a positive impact on members of the workforce,” says Matt.

Perhaps most importantly, they say, the Labs-wide consolidation effort of which Division 8000 is a part will have far-reaching impact for all members of the workforce at Sandia.

“The California site is playing an important role in a key strategic effort for the enterprise,” says Steve. “Modernized data centers today are actually the sum of multiple ones in geographically separate locations carefully integrated to deliver important resources to the workforce. Without a uniform component, Sandia’s data center will be incomplete.”

Acting NNSA chief visits California lab

**By Jeff McMillan**

Sandia’s Acting Administrator Bruce Held paid a visit to Sandia/Calfornia on Aug. 1 to learn about the site’s unique capabilities in weapons systems, information operations, combustion research, and biosciences, and the Livermore Valley.

Open Campus. On a tour of the Combustion Research Facility, Held learned about engine research from Mark Musklus, left. Also in the photo above are, left to right, senior manager Jeff Pontaux; Capt. Geoffrey Delasseur, military assistant to the NNSA acting administrator; Div. 8000 VP Steve Rottier, and Held.

(Photo by Dina Vouras)
Uncovering the mechanisms of virulence in pathogens

By Patti Koning

The original aim of the RapTOR (Rapid Threat Organism Recognition) Grand Challenge was to identify “unknown unknowns”—dangerous, virulent pathogens of unknown origin. Zach Bent (8623) and Steve Branda (8621) have now applied molecular biology capture approaches developed by the RapTOR team to a different and more complex problem. Until recently, determining what made pathogens dangerous was too expensive and time-consuming, but the capture methods overcome that barrier and could help researchers develop diagnostics and therapeutics to better combat drug resistant pathogens.

Analyzing pathogen’s gene expression during infection has been difficult because pathogen RNA molecules (“signal”) are generally outnumbered by host-derived RNA (“background”) in the sample by about 100-fold. RapTOR began to address this signal-to-background ratio problem with a negative capture method that uses affinity probes to capture and discard nuclear acids not of interest (e.g., host-derived) prior to sample analysis via Second Generation Sequencing (SGS). To amplify the pathogen signal, Zach turned to capture probes that selectively bind and recover pathogen nuclear acids for sequencing, a strategy referred to as pathogen capture.

“Our approach is very minimalist. It’s fast and cheap, which is important because it requires a large excess of probe, about 100 times more probe than sample,” says Steve. “We finely chop and tag pathogen nuclear acids to generate the probes. It’s crude, but it gets the job done. This method uses the entire genome, so every possible transcript can be captured and sequenced.”

A simple concept

The concept is simple: Saturate your sample with pathogen-specific probes; give the probes every opportunity to find their complementary nucleic acid partner; recover the hybridized probes on a column, wash extensively to disrupt non-specific interactions; and release the pathogen nuclear acids from the column for sequence analysis.

“It sounds straightforward, but carrying it out is tricky because the conditions have to be exact for the probe to find the target, grab it, and remain stable enough to isolate it from the sample,” says Steve. “Efficiently separating the target from the probe is key as well. You don’t want to waste time and money inadvertently sequencing the probe.”

Another challenge is making the probe discriminating enough to grab only nuclear acids from the pathogen, avoiding those from the host. This increases the degree of pathogen enrichment, which is critical to getting sufficient sequence coverage of the pathogen’s entire transcriptome at a reasonable cost. Zach and Steve’s goal was at least 100-fold enrichment.

Getting it right took about two years of painstaking research; Zach and Steve are grateful to the many interns and technologists who have helped on the project. Most improvements were incremental, but their breakthrough came with precise definition of the column washing conditions.

“We significantly raised the ionic strength of the washing buffer to increase the stringency of the wash. Suddenly almost all of the nonspecific binding we were getting went away. That brought our enrichment up from 10-fold to over 100-fold in a single step,” says Zach.

Seeing pathogens in high fidelity

Zach and Steve use pathogen capture in tandem with other molecular biology methods developed for the RapTOR project, and the results are quite amazing — the ability to see details of what the pathogen is doing, due to the sheer number and variety of pathogen gene transcripts that can be sequenced.

Zach puts the advance in perspective. “I spent all of my time in grade school looking at the in vivo expression of four different genes. This required an immense amount of work to get results of any significance,” he says. “With our new technique, instead of looking at a few genes, I can look at expression of all of the pathogen’s genes, several thousand of them, at once.”

This technique mitigates a significant barrier to research — the cost of sequencing. While sequencing remains a fixed cost, the cost of prepping the sample is small (about $20 to prepare and capture a sample), and the sample itself is rich in genetic material. By capturing the sample for amounts of interest, the researchers can load multiple samples on the sequencer and still get appropriate coverage depth. This yields better bang for the buck, in terms of sequencing costs, and also saves time because multiple samples are analyzed in a single sequencing run.

Zach and Steve tested the efficacy of their pathogen capture technique by analyzing in vitro infections. In a paper titled “Enriching pathogen transcripts from infected samples: A capture-based approach to enhanced host-pathogen RNA sequencing,” published in Analytical Biochemistry in March 2013, they reported 10- to 100-fold enrichment of reads mapping to the pathogen transcriptome, relative to untreated controls. This enrichment greatly increased the diversity of pathogen transcripts sequenced, as well as the coverage depth at which each transcript was sequenced.

They then closely studied F. tularensis at two critical transitions during infection: when the pathogen escapes from an internal membrane-bound compartment within the host cell, and when the pathogen begins replicating within the cytosol of the host cell.

“We saw what we expected: Two distinct gene expression profiles at those two transitions,” says Steve. Their work also revealed several hundred transcripts of unknown function, many of which are up-regulated (witched on) and therefore potentially important for pathogen survival and proliferation within the host cell. These results will be reported in a PLoS ONE article that is currently in press.

“We don’t have the resources right now to study those particular unknown genes,” says Zach. “Just the number of unknown genes we found is quite interesting, because Francisella has been studied extensively for two decades. The number of unknown, up-regulated genes we found in just this initial experiment shows that we really haven’t been seeing the whole picture.”

Understanding host/pathogen wargames

Moving forward, the researchers would like to study infections in even greater detail. Zach likens host/pathogen interactions to arms race on a microscopic level. “The pathogen resides, the host recognizes the pathogen counterattacks, and this goes on until one side wins,” he says. “Being able to look so closely at expression of all of the host and pathogen genes will let us figure out those key critical moments when the host is compromised and disease spreads.”

They want to expand their research to include animal studies to track the dynamics of infection at different physical locations, a particularly understudied dimension of infection. The speed and low cost of the pathogen capture-based technique would enable tracking of an infection as it spreads to different parts of the body.

“By being able to sample and analyze different physical locations, you can see how different body defenses are mounting a reaction, and what the pathogen is doing to survive,” says Steve. “Those have been really difficult experiments to carry out, and we don’t at all understand what it means for bacteria to survive in the liver versus a lung, for example. This is a completely different facet on the whole interaction between a pathogen and a host.”

In the future, pathogen capture technology could enable researchers to study bacterial gene function during infection with such precision that they can develop new countermeasures that are effective against drug-resistant strains. Therapeutics could be made to target specific bacterial pathogens and infection mechanisms entirely separate from those targeted by broad-spectrum antibiotics. By hitting multiple pathways at once, says Steve, a therapeutical could conceivably stop a pathogen in its tracks, preventing it from developing resistance to the new drugs.

Zach is also the principal investigator of an Exploratory Express LDRD to analyze the Yersinia enterocolitica transcriptome at very early time points in infection using pathogen capture technology. “We aren’t quite finished analyzing all of the data, but we have already made several exciting discoveries that shed light on the roles of its various virulence mechanisms,” says Zach.

In October, Zach and Steve will begin working on an LDRD-funded project led by Robert Meagher (8621) to build an automated device to perform pathogen capture on 96 samples simultaneously. “Right now, we have a very specialized setup and it still relies on a lot of manual labor,” says Zach. “We want this to be accessible and compatible with a typical lab setup, so that other groups can take advantage of our technique.”

Developing the automated device will take a year or so, but during that time Zach and Steve will conduct more studies to prove the technology. “With each new development, you can do more experiments than you could in the past, and different types of experiments as well,” says Steve. “It’s been a long time in the making, and there’s still much more work to be done, but we continue to get exciting results along the way.”

ZACH BENJ, in the foreground with Steve Branda, manipulates a pathogen capture reaction under high temperature to maintain stringent hybridization conditions so that binding specificity remains high, thus enhancing efficiency of the capture. (Photo by Oivo Vonna)
What’s not to love about California?
Steve Rottler reflects on his new role as Division 8000 VP

Lab News interview by Mike Janes and Patti Koning
Photos by Dino Vournas (Except where noted)

“I FEEL PRIVILEGED to be part of Division 8000,” says California site VP Steve Rottler.

“Lab News: You lived in Albuquerque for 28 years and are still a resident. How did you feel about moving to California?”
Steve Rottler: I was very excited. In fact, much earlier in my career I had hoped to go to California for an assignment. However, before anything could be arranged I was promoted to center director. My career took a slightly different turn, the opportunities became much narrower, and when I became an executive in 2005, I pretty much gave up any hope of ever coming to California.

When Paul [Hommert] called me about this opportunity on Thanksgiving last year, the only negative I could see was living apart from my wife for several years or more because of the need for one of us to remain in close proximity to our aging parents who live in north Texas. Everything else is positive: the site, the people who work here, the work that goes on in the division, the number of interfaces and opportunities that the lab has here in the Bay Area, and this fantastic place in which we live. What is there not to like, about living and working in the Bay Area? Nothing. It’s fantastic.

Lab News: You have a very strong background in nuclear weapons. Do you think that background is important at this particular time in leading this site? If so, why and how is it important?
Steve Rottler: I don’t know that it so much has to do with a particular moment in time. We have Bruce [Walker] and Jerry [McDowell] in New Mexico and the directors who have the primary responsibilities for the nuclear weapons program, and so we are blessed with much talent in this area. In the role I have out here, I believe my experience and background in nuclear weapons and the programmatic role that I’ve retained are valuable assets for this division and for the site.

One of our most important relationships is with our colleagues across the street at Lawrence Livermore. I know their key leaders, and feel I’m well known to most of them. I think that will be very helpful to the division and the lab. I think the experience and background that I bring and those established relationships will make it easier to maintain the trust-based relationship that underpins our very important strategic partnership with LLNL.

Understanding the context in which the NW program exists nationally and the forces that shape it are both important parts of developing strategy and engagement for our division in the rest of the work in the Laboratories. I think I bring that perspective, too, and it’s a useful tool to help our leadership team plan and move into the future.

Lab News: Do you have additional thoughts on the relationship between Sandia and Lawrence Livermore National Laboratory?
Steve Rottler: Our most important relationship is the 60-year strategic partnership with our colleagues across the street (LLNL). That relationship is even more important during this time of rapid change and adjustment in programs based here in California. These changes can create tensions in our relationship, but they also present opportunities and
we should exploit them. In any event, we should not allow the changes going on around us to alter our focus on continuing to strengthen this important relationship.

SR: In terms of a process for developing a division vision, I have to say that I don't really have one. I'm really primarily focused on achieving our laboratory vision, and on defining the role of our division in making the vision of the laboratory a reality. So when I think about Division 8000, I think about strategy and how to maximize our division’s impact on helping the laboratory realize its strategic plan.

Regarding high priorities, I would put at the top of the list our joint plan with LLNL for the development of the Livermore Valley Open Campus. It's not only differentiating for this division and for this site, but I also think it's critical for both LLNL and our laboratory. We talk often about the benefits to Sandia from having a presence here in California, and in my mind, the Livermore Valley Open Campus provides a means by which we can more fully realize these benefits.

The nuclear weapons program is an obvious priority. There is still some uncertainty about what the workload will be for California, but there's no question in my mind that the modernization programs are going to proceed, and our division will play a very important role in the program. I also see very exciting opportunities for this division in areas of emerging importance from a national security perspective, our work in biosciences, energy, transportation through the Combustion Research Facility, and cybersecurity. Those are areas of emerging importance, and for some, the funding opportunities exceed our ability to provide the resources necessary to do the work. They represent potential growth areas and areas for our division to have a very high impact on national security.

Before I came out here, I saw the LVOC as a very important asset to the laboratory, but something that anchored our California site. While that's true, I think the greater value may be in how the LVOC draws more of the lab into California. . . . LVOC positions us to use our California site location more strategically as a lab. A key part of my role as the site VP is to help communicate and drive this vision. The future of LVOC is exciting and I've told our LVOC team I want us to do everything we can to accelerate the realization of our vision. But by virtue of being in this part of the country, we are situated in the Bay Area with millions of people, thousands of companies, hundreds of educational institutions, and many different government entities. Our employees come from about a dozen congressional districts. The many interfaces and the number of people that are interested in what we are doing here at the lab are huge.

SR: After I'd been here for a few months, I had a personal epiphany about the potential for the LVOC to create greater connectivity for the lab here in California. Before I came out here, I saw the LVOC as a very important asset to the laboratory, but something that anchored our California site. While that's true, I think the greater value may be in how the LVOC draws more of the lab into California. The opportunities created by the LVOC can give lab program managers a gateway to the Bay Area and a reason to see value in exploiting our presence here to strengthen our capabilities and programs. This was probably well understood to others, but was something I realized only after being here for a few months. LVOC positions us to use our California site location more strategically as a lab. A key part of my role as the site VP is to help communicate and drive this vision. The future of LVOC is exciting and I've told our LVOC team I want us to do everything we can to accelerate the realization of our vision.

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STEVE REFLECTS on the evolution of Sandia's microfluidic devices.

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WATCHMAN

(Continued from page 1)

SANDIA and LLNL are teaming with six universities — University of Hawaii, Hawaii Pacific University, Virginia Tech, and UC Berkeley, UC Davis, and UC Irvine — on a project funded by NNSA’s Office of Defense Nuclear Nonproliferation Research and Development. The project is called WATCHMAN, or WATer CHerenkov Monitoring of Anti Neutrinos. There is some precedent for a detector of this scale. Japan’s Super-Kamiokanda Detector, or Super-K, has a massive 50-kiloton tank that stands 336 feet high. But as a neutrino observatory searching for proton decay, neutrinos, and cosmic rays, Super-K is not sensitive to reactor antineutrinos. Super-K uses ultra-clean water, not the doped water proposed for the WATCHMAN detector. Because the WATCHMAN detector will break so much new ground, the team is starting with basic research to optimize the design and location of the demonstration site of a smaller kiloton-scale gadolinium-doped water detector. They are about halfway through a two-year scoping study.

Understanding background at shallow depths

One challenge for a detector of this size is background radiation. The bigger the detector, the more background radiation it is going to pick up. One solution to this, says Peter, is to place the detector underground.

“At a certain depth, cosmic radiation disappears,” he explains. “But that kind of excavation would be very costly and time-consuming for a detector of this scale. We’re looking at what happens at shallow depths. Is there a more reasonable depth of a few hundred feet where background radiation drops off to a more manageable level? That’s something we don’t know because there just isn’t much research on background radiation at shallow depths, especially with a water-based detector. We are after a low signal-to-noise regime to optimize the detector’s effectiveness, so understanding background is huge.”

In particular, the study is looking at background radiation created by muons that can mimic antineutrinos. Muons are fundamental particles created when cosmic rays collide with molecules in the upper atmosphere. Every second of the day, muons are hurtling down to earth, the rule of thumb, says Peter, is that a muon passes through your thumbnail every minute. They eventually attenuate when they are absorbed or deflected by other atoms.

“Muons are very high energy particles that are not easily stopped. When they interact with rock, they basically rip apart the nuclei in the rock and create a shower of particles that can look like an antineutrino signal in the detector,” says Peter. A muon can also pass through a water-based detector and create radionuclides with different signatures, and mimic an antineutrino.

To understand how these phenomena affect background radiation at shallow depths, the WATCHMAN team is conducting a series of fast neutron measurements at the Kinshaldon Underground Research Facility (KURF), a science facility operated by the Virginia Tech Neutrino Science Center.

Splitting the problem

Early into the project, it became clear to the WATCHMAN team that a single detector could not encompass all of the muon interactions, so they split the problem. LLNL looked on radionuclides while Sandia focused on the neutron spectrum, specifically muon-induced fast neutrons with energies between 100 and 200 MeV.

THE MARS TEAM — Kevin Hulin (8136), Caleb Roecker (UC Berkeley), Peter Marleau (8132), Jen Brennan (8123), Mark Geiling (8132), and John Steele (8132). Not pictured is Dan Throckmorton (8125).

LLNL’s radionuclide detector, still in development, will be similar to the kilonet detector on a much smaller scale, about 3 meters across, with a tank that will hold gadolinium-doped water. “There has been no measurement of the production of radionuclides from muons interacting with water, so it’s not a well bounded problem,” says Peter.

Over the past year, the Sandia team members designed and constructed a one-of-a-kind detector that was delivered to the KURF site in early June. That detector, which the team dubbed MARS for Multiplicity and Recoil Spectrometer, combines two established modes of neutron detection to cover the entire energy spectrum of interest.

Think of it as a detector within a detector within another detector. MARS consists of a 20-centimeter thick pile of lead sandwiched between plastic scintillator wrapped in photo multiplier tubes to read out the scintillation light. The entire package is wrapped in pindle detectors to tag muons that enter MARS.

“We want to measure what is coming out of the walls of the cavern, not neutrons that are created within our detector by muon interaction,” explains Peter. The lead acts as a multiplier for high energy neutrons, so there are two modes of detecting neutrons. A high energy neutron can interact directly with the scintillator, which causes a large pulse of light that is captured by the photo multiplier tubes — this is the recoil. Neutrons at even higher energy levels interact with the lead, producing many more low energy neutrons — the multiplicity. The number of low energy neutrons produced is correlated to the energy of the neutron.

The antineutrino detector developed by Sandia and LLNL in 2008 found new life in MARS. “We were able to re-use the plastic scintillators with layers of neutron capture gadolinium from two detectors that were deployed at the San Onofre nuclear power plant,” says Peter. “We added more photo multiplier tubes to increase light collection.”

MARS was then placed in a trailer so it can be moved to three different locations within the mine to collect data at different depths. It is currently sitting at 600 feet, in a few months it will be moved to 350 feet and will finish the year of testing at 150 feet. This project is the first-ever continuous measurement as a function of depth.

Peter expects many in the scientific community to pay close attention to the WATCHMAN project as it develops. He describes the project as a good testbed for basic scientific research with the potential to make measurements of great interest to the scientific community.

“The idea of creating a detector based on gadolinium-doped water has been kicked around for some time, but no one has pursued it. We don’t have a choice — for long-range detection we need a large detector and gadolinium-doped water is possibly the only feasible option for a detector of that size,” says Peter.

“In addition, there is no antineutrino detector in North America today. It’s good to have several well-separated independent detectors with different systematic uncertainties observing the same phenomena as a cross check. WATCHMAN could be America’s contribution to neutrino astrophysics.”

Detecting Supernovas

There is another benefit to WATCHMAN — when complete, it will be among the best supernova detectors in the world. A core-collapse supernova produces an enormous burst of neutrinos. Knowledge gathered by measuring the type, time, and energy structure of those neutrinos can help answer many physics and astrophysics questions.

With gadolinium-doped water, WATCHMAN will be able to distinguish between neutrinos and antineutrinos. The number of neutrinos and antineutrinos as a function of time will be useful data for supernova physics models.

WATCHMAN will be smaller than Super-K, but that size could prove an advantage with a nearby supernova. The signal of Supernova 1987A, which occurred 168,000 light-years from Earth and was observable by the naked eye, overwhelmed Super-K.

(Continued next page)
I t’s only natural that Sandia would seek strong academ- 
ic alliances. The cultivation of ongoing partner- 
ships with key universities and colleges, the Labs has 
demonstrated time and time again, can lead to funding 
opportunities, increased entrepreneurship. They can 
also provide a pipeline to recruitment of future gen- 
erations of engineers and researchers.

The LVOC exists to enhance Sandia’s national secu- 
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and technology base through world-class collabora- 
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Construction unearths Cold War relics

By Patti Koning

Early in his career at Sandia, Tracy Walker (8949) heard rumors that the basement of his building, Bldg. 912, had once housed a fallout shelter. More than 20 years later those rumors were confirmed true when renovations on the building's foundation led to the discovery of emergency fallout shelter supplies lining the dugout earthen walkways below the building.

"We opened one of the boxes and found Civil Defense all-purpose survival crackers from 1962," says Tracy. "We brought out some of the supplies, cleaned them up, and showcased them at Family Day that year."

He did some research and learned that the newly discovered cache of fallout shelter materials was quite unusual. Tracy described the discovery and the history of Civil Defense shelter supplies in the March 2013 issue of the Watercooler [http://cfo.sandia.gov/watercooler/MarchArticles/stratMar13.html]. He writes:

"Civil Defense shelter supplies, consisting of food, medical and sanitation kits, and water containers, were produced by the federal government in the 1960s as fallout survival gear. A lot of national thought and preparation went into the contents and accompanying instructions for these supplies, and Sandia procured its share.

"Some of the supplies are definitely outdated. Being packaged in May of 1962, the four crackers just celebrated their 50th year in storage. A Civil Defense memo dated September 1976 confirms that due to rancidity, they should 'no longer be considered for human consumption.' Yet here they are still, packaged up nicely for the impending emergency 35 years after rancidity set in.

"All that is left of the wheat crackers is a single, empty metal container. Presumably, they were tastier in 1970. And the hard tack candy, which came in three flavors — red, green, and yellow — are gone, possibly because they were made with red dye #5. However, the still present sanitation kits are stuffed with interesting items, including all items necessary to turn the multitude of available water barrels into commodes."

"Some of the suppliers are listed on the containers. Of note, one of the companies that made the crackers is Sunshine Biscuits, and the still present sanitations kits are from Koats, Salinets and Cheez-Its today. Sunshine became a subsidiary of Keebler in 1996, and Keebler was bought by Kellogg’s in 1998.

"Thankfully, these materials were never needed, and they certainly have no continuing value. But they identify a time period when the nation as a whole was blanketed with a real fear of impending attack. Every community had an evacuation plan and a Civil Defense coordinator. Every school practiced 'duck and cover' nuclear attack drills learned from Bert the Turtle. The precursor to our Emergency Broadcast System (EBS) was to turn to CONELRAD radio at 640 or 1240 on the AM dial. Our outlook has changed, as have the needs in our 72-hour ready kits. I know some employees keep their own personal kit in their car or a limited-item version stashed in their offices for emergencies. Given that we spend a bunch of our time on site, I wonder why more don’t."

"A few individuals commented on Tracy’s Watercooler article, including Matt Hopkins (1516) whose grandpa, Joseph Romm, was the director of Civil Defense during the 1960s. Laura Sewers (3657) recalled growing up in Los Alamos with a fallout shelter of sorts in the crawl space beneath her house. There was a large metal container with food in it and several glass 1-gallon bottles filled with water. She and her brothers were under strict instructions to leave the supplies alone.

"Sometimes in the ’80s, we opened the metal food tin to learn what we would have had to subsist on — mostly freeze-dried meals and other things that I can’t recall. Since the danger had passed, we found it all amusing and wondered how long it would have sustained all five of us," she wrote. "Perhaps others who had these preparations occasionally had nightmares about an atomic bomb being dropped nearby — I know my mother and I both did. I think the lasting effect of this for me is attending to emergency preparedness and having an updated kit, mostly for power outages.

"To get a sense of the times that Laura describes, take a look at Nuclear War Survival Skills, published by Oak Ridge National Laboratory in 1979. An updated and expanded version was published in 1987 by the Oregon Institute of Science and Medicine. There have been several updates to the book, the most recent in 2012.

"In the foreword of the 1987 edition, Edward Teller describes civil defense as ‘the most peaceful and the most effective deterrent of nuclear war’ because ‘if [the Russians] cannot count on destroying us they will probably never launch their nuclear arsenal against us.’"

"Many of the supplies discovered below Bldg. 912 are listed in chapter 16, Minimum Pre-Crisis Preparations. The book also covers how to build six different types of expedient fallout shelters, surviving without doctors, improvised clothing, and basic needs like food and water. The 1987 expanded version of the book is available online for free at http://www.casm.org/nwws/s73p904.htm."
Giving back

Sandia/California Community Outreach Initiatives

Giving back is part of our culture at Sandia. We are passionate about serving the country, but at the same time we also feel strongly about supporting our local communities and ensuring that we are giving back. Whether we're encouraging children in their exploration of science, serving on boards of directors, volunteering to improve our community, or giving our time to support organizations and causes that move us, we are passionate about service.

At the California site, we serve our communities in a number of ways. We collect turkeys and fixings for Thanksgiving baskets for needy families, donate everyday items to support our troops overseas, volunteer our time at the DOE Science Bowl and Lego robotics tournaments, walk all night in the Relay for Life to fight cancer, help preserve the heritage of our community, and support causes close to our hearts through SHARE. We engage with the civic community, help young people explore career paths, and recognize outstanding high school and college students. The causes we support and the ways we choose to give vary greatly, reflecting the diversity of our workforce, but the goal is always the same — to strengthen the communities in which we live and work.

— Patti Koning

MAYNARD HOLLIDAY (8118) emcees a First Tech Challenge competition hosted by Robot Garden, a robotics-themed hacker-space, at GATE, a regional public-private partnership focused on green transportation and clean energy. Maynard is a volunteer Citizen Teacher, teaching robotics at Elmhurst Community Prep in Oakland, a recipient of the President’s Volunteer Service Award and, along with Daniel Casner (8136), a founding member of Robot Garden. (Photo by Dino Vournas)

SHARE — Margaret Quinn (3555) talks with a representative from Children’s Hospital & Research Center Oakland, one of more than 200 organizations that Sandians support through SHARE. (Photo by Randy Wong)

RELAY FOR LIFE — Cancer survivor Christy Turner (8237) proudly represents Sandia in the team captain lap at the 2013 Livermore Relay for Life. (Photo by Dino Vournas)

MANUFACTURING ACADEMY — At the first-ever Design-to-Manufacturing Academy, Bryant Morgan (82472) helps high school students explore career opportunities in manufacturing. (Photo by Dino Vournas)

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INNOVATION FORUM — Division 8000 VP Steve Rottler participates on the Innovation Panel at the Livermore Valley Chamber of Commerce’s Summer Luncheon Innovation Forum. (Photo by Dino Vournas)

BLUE STAR MOMS — Tim Shepodd (8220), Mary Fadhel Burton of Blue Star Moms, and her husband Carl look over the donations for Blue Star Moms collected at the Center 8200 holiday party. (Photo by Dino Vournas)

FAMILY SCIENCE NIGHT — A parent and child work together to build a “hoopster” (wingless airplane) from straws, Scotch tape, and index cards at Family Science Night. (Photo by Randy Wong)

TURKEY BRIGADE — Volunteers sort turkeys for the Tri-Valley Basket Brigade, organized by Sandia/California ombuds Reese Ramos (3D) and his wife Katherine Havener. On a single day last November, volunteers assembled 138 Thanksgiving baskets and 80 care packages from donated items and delivered them to needy families and the homeless. (Photo by Rich Washburn)

REGIONAL SCIENCE BOWL — Helena Jin (8256) keeps score in the final round of the Sandia/Los Positas regional DOE Science Bowl for high school. Sandia/California also runs a regional DOE Science Bowl for high school with Las Positas College and supports three additional Bay Area regional science bowls. (Photo by Dino Vournas)

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