Hide and seek

Sandia engineer helps design a way to expose suicide bombers before they walk into a crowd

By Nancy Salem

O
n the chilling list of terrorist tactics, suicide bombing is at the top. Between 1981 and the end of 2015, an estimated 5,000 such attacks occurred in more than 40 countries, killing about 50,000 people. The global rate grew from three a year in the 1980s to one a month in the 1990s to one a week from 2001 to 2003 to one a day from 2003 to 2015.

Terrorism experts say suicide bombings are pervasive because they generate publicity and require little expertise, resources, or planning. They instill fear and breed distrust in the public, a goal of groups determined to spread terror. Perhaps most importantly, suicide bombings are almost impossible to prevent.

“The suicide bomber can walk into a crowded place unnoticed and inflict a horrifying amount of death and destruction,” says Albuquerque businessman Robby Roberson. “It’s very hard to stop. There’s no technology to deal with it.”

Until now, Roberson says. His company, R3 Technologies, is working with a group of small businesses to develop a way to prevent suicide attacks by detecting concealed bombs before they go off. After a frustrating start, the group decided it needed more technical help and turned to the New Mexico Small Business Assistance (NMSBA) program, which pairs entrepreneurs with scientists and engineers at Sandia and Los Alamos national laboratories.

Turning things around

R3 found a partner in Sandia sensor expert JR Russell (6514) who, during the past two years, has helped bring the company’s Concealed Bomb Detector, or CBD-1000, close to commercialization.

“JR has been all over it and really turned things around for our company,” Roberson says. “He is ter-

(Continued on page 4)

WEARING A MOCK SUICIDE VEST, Albuquerque business-

nessman Robby Roberson stands in front of his com-
pany’s CBD-1000 bomb detector, being adjusted by Sandia scientist JR Russell. JR worked with R3 Tech-

ologies to iron out technical issues and bring the sui-
cide bomb detector close to commercialization.

(Photo by Randy Montoya)

Former Lock heed Martin CEO Norm Augustine addresses Sandians as part of the Labs’ National Security Speakers Series. (Photo by Randy Montoya)

Speaker Norm Augustine laments low US value given education, research

Former LM CEO describes need for increased funding in critical areas

By Neal Singer

Peppered his sobering remarks with wry humor, apt quotes, and sometimes surprising statistics in a speech at Sandia, retired Lockheed Martin chairman and CEO Norm Augustine delivered an analysis of America’s declining state of readiness to compete educationally, economically and, eventually perhaps, technologically in the international arena.

The solutions he proposed were increased funding for research and education, and a social adjustment that would value academics over athletics.

In terms of funding, he said, “Once when I advocated for more funding for research, [a colleague on a panel] warned me that the country has a serious budget problem. I told him that when I was a young engineer, I worked with a lot of airplanes too heavy to fly in the design stage, but none ever flew by taking out the engine.”

Among his comments regarding education, he said, “Teachers should be the heroes but you get what you cele-
brate. The highest paid employee [at some universities] is the football coach. What message does that send?”

$20,000 a pitch

He reported calculating that top baseball pitchers get $20,000 for every strike they throw.

“A pessimist,” he said, “is an optimist who sees the facts.”

He quoted a statement from Bill Gates: “When I see our high schools and compare them with what I see when traveling abroad, I’m terrified for our nation.”

His Feb. 11 talk, titled “The Foundation of National Security,” was part of Sandia’s National Security Speakers Series. It was presented in Steve Schiff Auditorium and video-linked to Sandia/Cali-

ifornia and to Sandia’s Washington, D.C., facility.

Augustine, a man with a resume that VP 1000 described in his introduction as “enough for any three men,” has had a wide view of American life. Among his many achievements and honors, he’s been under secretary of the Army, chairman of the Council of the National Academy of Engineering and the American Red Cross, and president of the American Institute of Aeronautics and Astronautics and the Boy Scouts of Amer-
ica. He’s taught at Princeton and served for 16 years on the Presidential Council of Science and Technology. He has been presented the National Medal of Technology by the...

(Continued on page 4)

Exceptional service in the national interest

Sandia Lab News

Volume 68, No. 4
February 19, 2016

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National Labs Day at Howard University

On Feb. 4, Sandia led the coordination of National Labs Day, a career fair at Howard University featuring 15 national labs, DOE, and NNSA.

The event was designed to introduce STEM students to career opportunities at the national laboratories.

(Continued on page 4)
That's that

I read an article a few years back — I think it was about a presentation by a popular business guru — that goes something like this: A traveling music teacher visits a kindergarten class to introduce the kids to some basic music concepts. Before beginning her lesson, she asks the kids how many of them can sing. Every single child laughs and raises his or her hand. What kind of silly question is that!? Everybody can sing!

Excellent, the teacher says, and proceeds to lead the kids through melodies and rounds, all while they nod and even some pop tunes. The kids all begin to sing along.

Five years go by. The teacher finds herself back at the same school, but this time with a lesson plan for 4th-graders. She realizes this is the same group of kids she'd taught as kindergartners. Oh, good, she thinks, these kids were fun. Before beginning her lesson, though, she asks the question again: How many of you can sing? Two kids out of the 22 in the classroom tentatively raise their hands. 

Speaking of Engineers Week, I hope you get a chance to read Div. 1000 VP and Sandia's Chief Technology Officer Rob Leland's fascinating essay beginning on page 6 that explores what he calls a "virtuous cycle," the synergy between science and engineering and what that means for Sandia. Here's a little sneak preview:

"Engineers deeply rooted in science is a common thread permeating much of Sandia's work. The intentional cross-pollination between scientific disciplines and the practical application of the resulting insight to challenging engineering problems is one of Sandia's great strengths and underpins our value proposition to sponsors and customers alike. Perhaps less appreciated are the ways in which our engineering skills can enable a new frontier in scientific discovery. On the occasion of Engineers Week, I'd like to share a few of these stories, and thereby offer the perspective that there is actually a virtuous cycle, a deep synergy between science and engineering that often enables our most exceptional results."

That's that.

See you next time. — Bill Murphy (MS 1468, 505-845-0845, wtumurphy@Sandia.gov)

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IN KEEPING WITH TRADITION, members of the Sandia Emergency Response Team pushed a nearly 13-ton truck — dubbed "The Beast" — through Gate E1, signaling the start of its service. This is the third squad Sandia has received since 2002, the most recent being Squad 2 in November 2013. The tradition of pushing a new truck into service stems from the days when fire departments used hand-drawn and horse-drawn steam engines. With the advent of motorized equipment, the ability to align the equipment and align the steam connections on the engines, leaving the firefighters to back the gear in after fire calls. Although Sandia does not have stalls typical of firehouses, the ERT continues a similar tradition. According to ERT Team Lead Ricky Romero (4236-1), the tradition goes, "If you push the truck in the first time, it will always bring you back home safely." (Photo by Randy Montoya)
Let the competition begin!

**Sandia in 3-D teams take on first design challenge**

By Jana Cuiper

If you can imagine it, you can print it. 3-D printing technology is accessible to everyone. No special skills or degrees required.

This message resonated with members of the workforce who enthusiastically gathered for the Sandia in 3-D (S3D) kick-off, held simultaneously in California and New Mexico on Jan. 12.

"Everyone can see the possibilities for this technology and learn how to use it," says Bonnie Antoun (8343). She spent several months working with Mike Hardwick (8240), deputy director for advanced weapons systems, and a team of 30 committee members to create the S3D design challenge.

With an ambitious set of objectives, S3D aims to increase awareness of 3-D printing technology, while providing a fun, creative, and friendly competition that is open to all. Working together in this informal setting creates an opportunity for future collaboration and cross-mission area synergy, all while demonstrating Sandia’s ability to create revolutionary design solutions using 3-D printing.

### Three design challenges

Participants can choose among three design challenges: a musical instrument capable of playing as many notes as possible, a piece of Sandia memorabilia that represents multiple mission aspects, or improvements to an existing product.

More than 300 attendees in New Mexico and California received a warm welcome from Mark Smith (1801), deputy director of additive manufacturing. He opened the event with an overview of Sandia’s 30-plus years of pioneering development and commercialization of additive manufacturing (AM) technology, also known as 3-D printing.

"You can do things with additive manufacturing you can do no other way," Mark says. "This technology has the advantage of design freedom at lower cost, with reduced waste, energy, and risk, and it has broad applicability throughout the laboratories."

For example, the WB-4 systems engineering team is committed to using 3-D printing in its product development. "3-D printing has the potential to be used for everything from low-risk tooling to high-risk critical components that fly with the warhead," says Mike Hardwick (8240). "The progress we make in engineering design and materials science will determine how extensively this technology is incorporated into the weapons program."

Mike says he hopes the design challenge will inspire creativity, innovation, and learning that contribute to Sandia’s collective ability to move forward with this technology. "One way to accelerate our AM work is to engage bright and inquisitive minds and draw upon their expertise and passion," he says.

### Bringing together diverse planning committee

Diversity and inclusion are at the core of the 3-D Challenge, so Bonnie, as committee leader, knew the planning team needed to reflect that. She branched out beyond her network of technical colleagues to recruit people who might not typically participate in planning an event like this.

"We needed the perspective of those who know about and understand 3-D printing and those who are not familiar with it," Bonnie says. "Someone may feel they cannot contribute because they don’t have that background, but those are exactly the people we wanted to have on the committee."

A key aim is to encourage people to step outside their comfort zone in creating their challenge teams and designs. Teams that combine technical and non-technical members will be awarded extra points for diversity.

"So many people here have never seen this," says planning committee member Jim Brennan (8625). "It’s great to see how excited they are to participate. There is no barrier to entry so you don’t have to be afraid to try it."

Kevin Connelly (8343), also on the committee, talked with an attendee at the open house who reported being artistic but with no design background. "That’s perfect," he says. "The goal is to get people from different backgrounds to interact over their ideas."

### Incorporating diversity

As part of their design submission, the teams will define how they incorporated diversity. Among the 36 teams registered, most are mixed gender and include an age range from high school intern to undergrad researcher, to engineers and professionals with up to 20 years of lab experience. Some teams combine administrative and mission support professionals with mechanical and materials science technologists.

"Diversity often shows up in unexpected ways," says Bonnie. "People are surprised to discover just how diverse they are once they take the time to get to know one another and build relationships. We see this as a catalyst for people from different areas and backgrounds to link up and make connections."

Teams can win prizes in addition to bragging rights. The organizing committee is planning special 3-D-printed awards for the winning teams, as well as commemorative 3-D-printed coins for each participant. An event to announce the winners and showcase all of the entries is planned for early April.

A second design challenge kicks off in April as well, and a third challenge is slated for July. Current teams may continue to work together and new teams will be welcomed at the beginning of each session. The planning committee is considering new challenge projects and accepting suggestions on the S3D wiki.

"We will continue to emphasize creativity as well as technicality in our future challenges," Bonnie says. "Some of the challenges may build on earlier challenge ideas, and teams will be encouraged to demonstrate diversity and inclusion."

A range of training options is available for participants to learn the needed design software and printing skills, and 3-D hours are available for this. 3-D printing labs have been set up in New Mexico and California for teams to print their own designs.

Contact Bonnie Antoun at 925-294-4707 or visit the S3D wiki to stay informed about S3D events and plans for the upcoming challenges.
Bomb detector

(Continued from page 1)

The device is designed to detect bombs that current metal detector technology would miss and is intended for screening areas such as airports, embassies, public and government buildings, border crossings, transportation hubs, and military compounds. It is portable and could also be used at special events or unexpected threats.

A vital tech transfer tool

The New Mexico Small Business Assistance (NMSBA) program was created in 2000 by the state legislature to bring national laboratory technology and expertise to small business in New Mexico, generating economic development with an emphasis on rural areas. The program has provided more than 2,300 small businesses in New Mexico with $43.7 million worth of research hours and materials. It has helped create and retain 4,086 New Mexico jobs at an average salary of $38,488, increase small companies' revenues by $280 million, and decrease their operating costs by $85 million. These companies have invested $68.3 million in other New Mexico goods and services and received $77.1 million in new funding and financing.

R3 Technologies was among 364 small businesses in 2014 that participated during 2013 in NMSBA. In addition to Sandia and Los Alamos, the program contracts with the New Mexico Manufacturing Extension Partnership, University of New Mexico Management of Technology program to the New Mexico Tech Department of Management, and the New Mexico Manufacturing Extension Partnership, University of New Mexico Management of Technology program to the New Mexico Tech Department of Management.

Norm Augustine

(Continued from page 1)

president of the United States, and five times received the Joint Chiefs of Staff Distinguished Public Service award. He also chaired a prestigious National Academies group that produced the paper, Rising Above the Gathering Storm, which advocated more than a decade ago for increased attention to education and research.

Citing Russia's recent experience, he said that "without a strong economy, there could not be a strong defense," because taxes from the economy pay for research that "strengthens a country. Without a strong defense, there cannot be a strong economy," he said. "The two are interconnected.

going where the high IQs are?

He said one executive had said that if America couldn't get its educational act together, he was going to take his company "where the high IQs are."

Augustine presented a number of statistics that seemed to show that US students are achieving less than they did decades ago, that the number of students getting degrees in science and engineering are far too low, and that US "world class research institutions" like Bell Labs are declining in number. He criticized cutbacks in government funding that have led universities to increase tuition costs for science and engineering majors, believing that an engineering education costs more. The long-term result of job creation, he said, should restore parity in tuition.

Draconian increases in tuition

In California, he continued, "Draconian cuts in budgets and signals to determine the presence of a potential threat. If the person is not carrying a threat, the return signal is in the same polarity as when it was transmitted," Roberson says. "A threat will rotate the polarity of the signal, and it comes back differently."

The system sets up in about 15 minutes and can be checked while moving through the beam field. And we hope to extend to the 90 times, Roberson says. "We want to take movement out of the equation. People who want to protect their citizens want to detect at a distance, keep the threat away. They want to scan 10 and 10 times, but before they get too close."

Roberson says algorithms are being finalized that will allow screening at greater distances while people are moving.

System reached a plateau

The original technology was developed by the Albuquerque company R3 Technologies as a hand-held, radar-based sensor that police could use to scan people moving at a distance who they suspected might be armed. It evolved into a stationary system. "It was after 9/11, and there was a thought that we could change our approach and see if we could detect suicide bombers," Roberson says.

Starting a third NMSBA project

Roberson says the CBD-1000 will cost about $50,000 and that several hundred units have been produced. The device is patented, and the company has received inquiries from Pakistan, Afghanistan, Singapore, Kuwait, Saudi Arabia, and Nigeria, he says.

Roberson hopes to go to market this year. His business group has worked with R3 under two NMSBA projects over three years and started a third in January to help the product by further improving speed, distance, and accuracy. The group meets weekly. "We all clicked as people," R3 says. "We have a common focus on research in that direction. Everybody brings their technical expertise. These are energized people who are the poster child for a highly effective team. It doesn't feel like work to me. I'm lucky to work with them."

R3 says he enjoys helping a small business. "It's good for our community," he says. "Helping someone succeed helps us succeed, too, as a lab. I get to see science though the eyes of business people. And I've learned things that will help me in my work."

R3 says his suicide-bomb detector resonates with Sandia's national security mission. "We want to help our nation protect our people, our cities," he says. "If we do this one life, we can make a difference. The opportunity to make us safer from attacks is one of the idealistic things that drive us."

Some of the companies that have invested $68.3 million in other New Mexico goods and services and received $77.1 million in new funding and financing.

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The CBD-1000 uses X-band radar to detect metallic and non-metallic explosives. Roberson says it can detect ball bearings, glass, nails, ceramics, rocks, and other materials frequently used as shrapnel in suicide vests.

The scan takes about 1.3 seconds and an operator, who does not need a working knowledge of radar, can be trained in 30 minutes. The system sets up in about 15 minutes and can be checked while moving through the beam field. And we hope to extend to the 90 times, Roberson says. "We want to take movement out of the equation. People who want to protect their citizens want to detect at a distance, keep the threat away. They want to scan 10 and 10 times, but before they get too close."

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Sandia activities mark 2016 Engineers Week
National Security Speaker Series presents Engineers Week speaker
Johns Hopkins Applied Physics Lab CTO Jerry Krill on ‘Engineering at the Edge of Knowledge’

Sandia’s National Security Speaker Series will mark National Engineers Week on Tuesday, Feb. 23, with a talk on “Engineering at the Edge of Knowledge” by Jerry Krill, chief technology officer of the Johns Hopkins University Applied Physics Laboratory (APL). He will speak in Steve Schiff Auditorium from 10:30-11:30 a.m.

APL, the nation’s largest university-affiliated research center, does research and development on behalf of the Department of Defense, the intelligence community, NASA, and other federal agencies.

Krill became its assistant director for science and technology and CTO in October 2013, overseeing the laboratory’s 5,000-plus staff.

He was APL’s assistant director for programs from 2005 to 2010, responsible for more than 700 programs. He also co-led NASA design and mission reviews for the APL-built spacecraft New Horizons and the Van Allen Probes.

From 2001 to 2005, Krill served as head of the power projection systems and CTO in 2005, responsible for more than 700 programs. He also co-led NASA design and mission reviews for the APL-built spacecraft New Horizons and the Van Allen Probes.

From 2001 to 2005, Krill served as head of the power projection systems branch of APL’s technical development agent, he was responsible to the Navy CEC program manager for meeting an accelerated, congressionally directed flight introduction timeline.

In 1996, he served as technical lead for the Navy’s “Mountain Top” advanced concept technology demonstration.

Krill, a member of the Johns Hopkins University Whiting School of Engineering’s National Advisory Council, holds 21 patents and has written more than 100 papers and major technical documents.

He received the American Society of Naval Engineers’ “Jimmie” Hamilton Award, was named a Maryland Daily Record Innovator of the Year, and was inducted into The Clark School Innovation Hall of Fame at the University of Maryland, College Park.

He is featured in the book CTOs at Work and co-authored the book Inventing Innovation into Organizations.

He earned bachelor’s and master’s degrees in electrical engineering from Michigan State University and a doctorate, also in electrical engineering, from the University of Maryland.

National Engineers Week is celebrated each February, this year from Feb. 21-27. The National Society of Professional Engineers says it’s a time to increase public dialogue about the need for engineers, celebrate how engineers make a difference in the world, and bring engineering to life for children, parents, and educators.

On next page . . . an essay by Sandia VP and Chief Technology Officer Rob Leland

‘Synergy between science and engineering enables exceptional results at Sandia’

You know you’re an engineer when …

Sandia’s Engineering Sciences Center helped mark National Engineers Week with a contest, asking Sandians to complete the sentence, “You know you’re an engineer when …” The center received dozens of entries from around the Labs. The winner will be announced Feb. 23 during the Engineers Week celebrations at Sandia.

A sample of some of the entries:

- you wear two pedometers; the second is redundant should the first one fail
- you build a workshop and when it’s finished you invite all your friends (also engineers) and have squares laid out so they can check your work — which they do without you saying a word
- you rearrange the egg carton to optimize the mass properties
- you schedule and develop a project plan for your midlife crisis.
- thawing frozen chicken becomes a heat transfer problem
- you communicate with a pair of graphs rather than paragraphs
- you judge the success of a B2B not by the quality of the food, but by how fast your charcoal was ready to cook on
- a beautiful woman asks for a KISS and you explain the matching algorithm
- you leave your roommate a phone message in Fortran and Eubank intersection street light (the point where no one will ever be as fascinated with how the matching algorithm works as much as the dates it matches you with)
- you are as fascinated with how the matching algorithm works as much as the dates it matches you with
- you recognize your co-workers by their shoes more than their faces
- you are called an extrovert for staring at other people’s shoes
- faced with a lack of problems to solve, you invent some
- you personally know every character in the “Dilbert” comic strip
- you calculate the area of medium and large pizzas to see which is a better deal
- Edison, Faraday, Tesla, Fourier and Laplace start to sound like good names for your dog
- faced with a lack of problems to solve, you invent some
- your pencil
- looking at your co-workers’ shoes while talking to them, instead of your own, is considered confrontational
- even your wife knows all the words to the Engineer’s Cheer (true story): E to the x, dy, dx/E to the x, dx/Cosine, secant, tangent, sine/3.14159/Square root, cube root, BTU/slap stick, slide rule, Hail Purdue
- your kids say, “Dad, I don’t want to know the theory, all I want is the answer”
- you understand the most dangerous weapon invented is your pencil
- you can’t decide between duct tape and WD-40
- you can’t decide between duct tape and WD-40
- you look forward to assembling IKEA furniture
- you are an extrovert for staring at other people’s shoes
- you have a clock in your office with equations instead of the dates it matches you with
- even your wife knows all the words to the Engineer’s Cheer (true story): E to the x, dy, dx/E to the x, dx/Cosine, secant, tangent, sine/3.14159/Square root, cube root, BTU/slap stick, slide rule, Hail Purdue
- your spouse/significant other won’t allow you to dress properly, so you offer to fix it
- faced with a lack of problems to solve, you invent some
- you understand the most dangerous weapon invented is your pencil
- you look forward to assembling IKEA furniture
- you have a clock in your office with equations instead of the dates it matches you with
- even your wife knows all the words to the Engineer’s Cheer (true story): E to the x, dy, dx/E to the x, dx/Cosine, secant, tangent, sine/3.14159/Square root, cube root, BTU/slap stick, slide rule, Hail Purdue
- your kids say, “Dad, I don’t want to know the theory, all I want is the answer”
Synergy between science and engineering enables exceptional results

By Rob Leland, Div. 1000 VP and Chief Technology Officer

E
nduringly deep in science is a common theme permeating much of Sandia’s work. The intentional cross-pollination between scientific disciplines and the practical application of the resulting insights to challenging engineering problems is one of Sandia’s greatest strengths and underpins our value proposition to sponsors and customers alike. Perhaps less appreciated are the cases in which science and engineering skills enable a new frontier in scientific discovery. On the occasion of Engineer Week, I’d like to share a few such stories, and thereby offer the perspective that there is actually a virtuous cycle, a deep synergy, between science and engineering that often enables our most exceptional results.

**The Red Storm story**

Engineering to enable world-class computational science

In 2001, Sandia was seeking to acquire a new supercomputer, and the procurement was off to a rocky start. The Labs had issued a detailed request for proposals for the new system, but neither of the proposals received met the requirements. One of the companies, however, was willing to work with Sandia to build a system to the Labs’ architectural specifications. Sandia ultimately awarded the contract to Cray Inc., and over the next 30 months Sandia scientists and engineers worked side-by-side with Cray personnel to create the new system, code-named Red Storm. Completed in 2004, Red Storm served as Sandia’s primary high-performance computing resource for the engineering and science needed to maintain the nation’s nuclear weapons stockpile, and also was used on occasion to meet other critical national security needs. For example, in 2008, Red Storm played a crucial role in enabling the U.S. military to shoot down a defective satellite that threatened to fall to Earth.

Very successful in the broader marketplace

For the complex engineering simulations it was designed to run, Red Storm was the world’s fastest supercomputer. It also proved very successful in the broader marketplace due to its ability to efficiently solve a wide range of scientific and engineering problems. In fact, over the subsequent decade, the family of systems based on the Red Storm architecture became Cray’s most successful product line, selling with more than 120 descendants around the world.

“I believe Red Storm’s success came about fundamentally because Sandia is an outstanding engineering institution. That, and the experience gained in the development and implementation of some of our previous generations of leading-edge supercomputing platforms, translated into a clear design philosophy and sound judgment about just how far to push the state of the art — far enough to achieve breakthrough performance but not so far as to become untenable in that technological era. This, and the process that led to the change in the depth and breadth of computational science that could be performed at national laboratories, universities, and companies around the world, is why Red Storm ceased to be a powerful machine in our context. It became Cray’s most successful product line, and that’s why Cray is the most popular supercomputer architecture.”

**“I believe Red Storm’s success came about fundamentally because Sandia is an outstanding engineering institution.”**

The evolution and structure of the sun: Jim Bailey’s research

Jim Bailey is a Sandia National Laboratories physicist who has spent his entire career at Sandia. Jim holds a PhD in physics from the University of California, Berkeley. His expertise is in plasma physics and the interaction of high energy particles with matter. He is known for his work with the Z machine at Sandia.

Jim Bailey’s research on the evolution and structure of the sun has been both fundamental and applied. His work on the Z machine, a high-energy plasma source, has contributed to our understanding of the sun’s interior and has applications in the development of nuclear fusion reactors.

**“Conducting experiments like these in Z’s extreme environment is only possible due to leading-edge, highly innovative engineering. One example of this engineering is the development of an explosively driven, ‘ultrafast’ closure valve.”**

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**“Conducting experiments like these in Z’s extreme environment is only possible due to leading-edge, highly innovative engineering. One example of this engineering is the development of an explosively driven, ‘ultrafast’ closure valve.”**

**Z MACHINE’S enormous power creates extreme states of matter, producing pressures more than three times that at the center of the Earth, and temperatures more than twice that at the center of the sun. The machine is used in weapons and materials testing, in basic research, and in solving science questions.**

ATOMIC CLIMATE MODEL SIMULATION performed by Mark Taylor using Sandia’s atmospheric modeling code on Jaguar, the Oak Ridge National Laboratory system derived from the Red Storm architecture. At the time this was the most detailed and most advanced integration performed to date and led to new insights regarding global precipitation patterns.

**“I believe Red Storm’s success came about fundamentally because Sandia is an outstanding engineering institution.”**
A Sandia-led team has developed a way to make a magnetic material that could lead to lighter, cheaper, and better-performing high-frequency transformers, needed for more flexible energy storage systems and widespread adoption of renewable energy. Portable energy storage and power conversion systems, which can fit inside a single semi-trailer, could make it cost effective to rapidly install solar, wind, and geothermal energy systems in even the most remote locations.

"Such modular systems could be deployed quickly to multiple sites with much less assembly and validation time," says Sandia researcher Todd Monson of Nanoscale Sciences Dept. 1124, who led the team with Stan Atcitty of Energy Technologies and System Solutions Dept. 6111. The magnetic material depends on a method Sandia developed to synthesize iron nitride ($\gamma'$-Fe$_4$N) powders by ball-milling iron powders in liquid nitrogen and then ammonia. The iron nitride powders are then consolidated through a low-temperature field-assisted sintering technique (FAST) that forms a solid material from loose powders through the application of heat and sometimes pressure. The FAST method enables the creation of transformer cores from raw starting materials in minutes, without decomposing the required iron nitrides, as could happen at the higher temperatures used in conventional sintering. Previously, the $\gamma'$ phase of iron nitride has only been synthesized in either thin film form in high-vacuum environments or as inclusions in other materials, and never integrated into an actual device.

"FAST enables the net-shaping of parts, meaning that iron nitride powders can be sintered directly into perfectly sized parts, such as transformer cores, which don't require any machining," Todd says. Due to its magnetic properties, iron nitride transformers can be made much more compact and lighter than traditional transformers, with better power-handling capability and greater efficiency. They will require only air cooling, another important space saver. Iron nitride also could serve as a more robust, high-performance transformer core material across the nation's electrical grid.

So far, Todd and his colleagues have demonstrated the fabrication of iron nitride transformer cores with good physical and magnetic characteristics and now are refining their process and preparing to test the transformers in power conversion test beds.

By Stephanie Holinka

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"Advanced magnetic materials are critical for next-generation power conversion systems that use high-frequency linked converters, and can complement Sandia efforts in ultra-wide bandgap device materials for improved power electronics systems. They can withstand higher frequencies and higher temperatures, which ultimately result in high power density designs," says Stan. Todd, Stan, and their team built on Sandia’s expertise in power electronics and magnetic materials in strong collaborations with researchers at the University of California, Davis, and Arizona State University, who helped with materials processing and systems-level modeling. Team members from Sandia and UC Davis have filed a patent application for the materials synthesis process. The work is part of a larger, integrated portfolio of projects funded by DOE’s Energy Storage Program in the Office of Electricity Delivery and Energy Reliability.
Silicon has long been the go-to material for semiconductors that power the electronic world. Now scientists are looking far beyond that omnipresent element to materials that could make everything from computers to power grids to electric cars more mighty and energy efficient.

By Nancy Salem

Electrical power doesn’t travel a one-way street. In a technology called power electronics, it is converted from one form to another when you plug in a computer, drive a car, or flip on a light.

“Power electronics use semiconductor devices such as transistors, diodes, and thyristors to control the flow of electrical energy by switching electronic circuits,” says electrical engineer Bob Kaplan (1768), who is leading a Laboratory Directed Research and Development (LDRD) project exploring new, more powerful and energy-efficient semiconductor materials. “If you want to convert a DC signal into an AC signal, you have to do it in the actual circuit that does that. But the basic idea is to turn the DC signal on and off.”

Semiconductor devices are switching systems that convert voltages and currents. The switches have been made of silicon since about the 1950s when semiconductor devices were first developed, replacing in many applications power conversion that uses transformers, or coils of wire around magnetic cores. Silicon is at the center of all microprocessors, computer chips, cell phones, and more. “Silicon is the core material that the device that functions as a switch is made of,” Bob says. “When semiconductor devices were invented, people started making big transistors that could handle large amounts of power.”

Because power electronics process substantial amounts of electrical energy, and energy is lost when power is converted, there has been a move over the past decade to replace silicon with other materials that would be more energy efficient. “The more you can reduce the loss, the better the energy efficiency,” Bob says. “Power electronics had been viewed as a not-so-exciting area in the past. But now there is a resurgent interest in it.”

Bandgaps and energy

The new semiconductor materials are referred to as wide-bandgap semiconductors, which have a fundamental property, an energy range in a solid where no electron states exist. In the electronic band structure of solids, the bandgap generally refers to the energy difference in electron volts between the top of the valence band and the bottom of the conduction band in insulators and semiconductors. If the valence band is full and the conduction band is empty, electrons cannot move in the solid. But if some electrons transfer from the valence to the conduction band, then current can flow. So bandgap is a major factor determining the electrical conductivity of a solid.

Wide bandgap refers to higher-voltage electronic systems can be built.

Wide bandgaps have already revolutionized lighting, particularly in the area of light-emitting diodes, or LEDs, which are widely available and are replacing incandescent and fluorescent bulbs. But as transistors, or switches, in modern power electronics, they also have the potential to vastly improve the performance of electrical power grids, electric vehicles, motors for elevators and HVAC systems, and even computer power supplies. Smaller, faster switches mean less loss of power. “Faster switching also means you can make other parts of the circuit smaller, such as capacitors and inductors,” Bob says.

Wide bandgap has the potential to substantially reduce the estimated 10 percent energy loss between generating electricity and transmitting it into a home or business. “In a decade or two, the giant transformers in your neighborhood distributing power from the electric grid to homes, which now weigh 10,000 pounds, could be replaced by things the size of a suitcase that weigh 100 pounds,” says Sandia Fellow Sandia Fellow and materials scientist Jerry Simmons (1000).

And if electric vehicles could tap the potential for wide bandgap power electronics to withstand higher temperatures, they might not need a liquid cooling system, reducing the system’s complexity and improving vehicle range because the car would weigh less. “There are non-trivial applications as well,” Bob says. “The military wants small power converters on unmanned aerial vehicles, and the Navy is interested in electric ships. You want as much power as you can get in a confined space. These advantages are pretty universal.”

Leapfrog to the generation after next

Sandia is researching Sc and GaN, but it’s also working to leapfrog over those next-generation materials to the generation-after-next, wide-bandgap semiconductor materials like aluminum nitride (AlN), which has a bandgap of 6.2 eV. The Ultra-Wide Bandgap Power Electronics Grand Challenge project that Bob is leading is at the end of its first year. Grand Challenges are three-year LDRD projects that focus on bold, high-risk ideas with potential for significant national impact. Potential benefits include shrinking device size and high-temperature operation become even greater with ultra-wide-bandgap materials,” Bob says. “We’re also interested in other harsh environments. There the challenges become greater.”

Why switch?

Different methods exist to convert electrical energy from one form to another. For example, direct current (DC), or constant voltage can be converted to a lower DC voltage by connecting two resistors in a series arrangement known as a voltage divider. But that method of conversion is inefficient and wastes much of the power as heat. An alternative approach is to switch the DC voltage on and off, and take the average of the resulted on-off signal. That switching approach is known as power electronics and is much more efficient, so that little power is wasted as heat. The switching approach also allows for a wider variety of types of power conversion, for example, from a lower DC voltage to a higher DC voltage, from DC to alternating current (AC), from AC to DC or from one AC frequency to another.

Jump ahead of the game

If you want to convert a DC signal into an AC signal, then current can flow. So what is the bandgap? According to Bob, the bandgap is a major factor in determining the electrical conductivity of a solid.

The bandgap is significantly larger than one electron volt (eV), typically at least three eV. The bandgap of silicon is 1.3 eV and gallium arsenide, another common semiconductor material, is 1.4 eV. Wide bandgap semiconductor materials such as silicon carbide (SiC) and gallium nitride (GaN) allow devices to operate at much higher voltages, frequencies, and temperatures than the conventional materials, so much more powerful, cheaper, and more energy-efficient electrical conversion.
Opportunity knocks

By Nancy Salem

The Eastern Band of the Cherokee Indians is considering an alliance with Sandia that could take its information technology system to a higher level and potentially spur economic development.

Tribal representatives toured the Labs on Jan. 25, visiting the Cyber Engineering Research Laboratory (CERL) and the Data Center. “It was a wonderful experience,” says Anita Lossiah, a Tribal Council member from the Yellowhill community in western North Carolina. “It was a learning experience to see what Sandia has to offer the tribe, very informative.”

Vice Chief Richard Sneed says the Eastern Cherokee want to enhance and advance the tribal government IT infrastructure with a focus on cybersecurity, emergency management, and data center systems. “If we were to enter into a relationship with Sandia we could implement best practices that are known and have been tested,” he says. “It could serve our people better to partner on the front end instead of starting from scratch.”

Andrew Conseen Duff, technology adviser to the Tribal Council, says it is important that IT infrastructure meet industry-based standards and be secure and defendable. “We want to remove vulnerabilities,” he says. “Information used wrongly can be devastating.”

IT a trillion-dollar business

Sneed says enhanced IT could produce economic development opportunities in the Internet and emergency response fields. “IT is a trillion-dollar business across the globe,” he says. “If our tribe builds a solid infrastructure we can look to a clear roadmap into new areas that could be a boon for economic development.”

Conseen Duff says the Eastern Cherokee delegation heard the word opportunity spoken often during the Sandia presentations. “Every time I heard it, I listened closely,” he says.

Sneed says government is often reactive instead of proactive. He says he was inspired by the Sandia scientists who spoke to his group. “Just to know there are folks who spend every waking hour engaged in research and development is encouraging from a government perspective,” he says. “It would be beneficial and more cost-effective to be able to not be reactive but to have a plan knowing what the outcome is going to be. It is not an area where you want to be wrong.”

Curtis Keliiaa (9336), principal investigator for Tribal Cyber Infrastructure Assurance, says Sandia’s tribal strategic partnerships address national and tribal cyber critical infrastructure challenges regarding modernization, protection, security, and resilience. His team has developed eight deep science, engineering, and technical interdisciplinary abilities drawn from across Sandia and designed to apply to the 16 Department of Homeland Security defined critical infrastructure sectors.

Curtis says his group, in coordination with Tribal Government Relations, has worked with or is currently working with tribes in the western, northwest, and southwest United States. “The Eastern Band of Cherokee Indians visit to Sandia was very well received and provides potential opportunity to work in the eastern region of the United States to the mutual benefit of the nation and the tribe,” he says.

Sneed and Lossiah say the next step is to take what they’ve learned back to the tribe and review and discuss the partnership potential.

Sneed says the Eastern Cherokees have new executive and Tribal Council leadership and are looking to a dynamic future. “We’re on the precipice of a lot of growth potential,” he says. “We want to see where we can go with infrastructure. If we have a solid foundation we can go to many other places. We feel an energy. It’s an exciting time for the tribe.”

Ancestral home in North Carolina

The Eastern Band of Cherokee Indians is one of three federally recognized Cherokee tribes, the others being the Cherokee Nation and the United Keetoowah Band of Cherokee Indians, both in Oklahoma.

Eastern Cherokees explore IT and partnership at Sandia

BIG DATA — David Martinez (9324), project lead for Scientific Computing Systems, gives members of the Eastern Band of Cherokees delegation a tour of Sandia’s Data Center. Tribal Vice Chief Richard Sneed (center in the blue shirt) says he was impressed by the center’s water-cooled system. “It’s counterintuitive — water and circuitry — but when you learn how much energy is saved using water to cool everything instead of air, it is just amazing,” he says.

(Photoby Randy Montoya)
How to submit classified ads

DEADLINE: Friday noon before week of publication unless changed by holder.
Submit by one of these methods:
EMAIL: Michelle Fleming (classified@sandia.gov)
FAX: 844-6464
MAIL: MS 1468 (Dept. 365)
INTERNET WEB: On internal web, click on News Center, then on Lab News link, and then on the very top of Lab News homepage "Submit a Classified ad.
If you have questions, call Michelle at 844-4902.

Because of space constraints, ads will be published in the order they are received.

Ad rules
1. Limit 18 words, including first name and last name and home phone number (If you include a web or e-mail address, it will count as two or three words, depending on the address).

2. Include organization and full name with the ad submission.
4. Type or print ad legibly; use acceptable abbreviations.
5. One ad per issue.
6. We will not run the same ad more than once.
7. No "for rent" ads except for real estate.
8. No commercial ads.
9. For active Sandia members of the workforce, retired Sandians, and DOE employees.
10. No "for sale" ads for real estate.
11. No "for sale" ads for real estate.
12. We reserve the right not to publish any ad that may be considered offensive or in bad taste.

MISCELLANEOUS

ARMOUR, dark finish, $275; entertainment center, oak finish, $100; residentia

MISCELLANEOUS

ARMOUR, dark finish, $275; entertainment center, oak finish, $100; residential

LEATHER COACH, beautiful, like new condition, 6’10” wide, Oakwood color, very comfort-

TIMBERWOLF WEB, New Orleans, 3-

DRUM SET, 5-pc., Tama w/Zild-

ELECTRIC MOWER, Homelite, 12-

KID’S SKIS: Salomon Jr., Marker

DINING TABLE, high-top, w/2

FILM CAMERA, Nikon AF N6006

NINTENDO DSI, pink, w/>20

ELECTRIC MOWER, Homelite, 12-

KID’S SKIS: Salomon Jr., Marker

DINING TABLE, high-top, w/2

DINING TABLE, high-top, w/2

MILEPOSTS

New Mexico photos by Michelle Fleming

John Cerutti 4982

Jeff Rumine 49

Steve Sanderson 4982

Victor Rinkus 35

Mark Smith 35

1801

12. WE reserve the right not to publish any ad that may be considered offensive or in bad taste.

MISCELLANEOUS

ARMOUR, dark finish, $275; entertainment center, oak finish, $100; residential

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TIMBERWOLF WEB, New Orleans, 3-

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DINING TABLE, high-top, w/2

FILM CAMERA, Nikon AF N6006

NINTENDO DSI, pink, w/>20

ELECTRIC MOWER, Homelite, 12-

KID’S SKIS: Salomon Jr., Marker

DINING TABLE, high-top, w/2

DINING TABLE, high-top, w/2
By Valerie Larkin

On Feb. 4, Sandia led the coordination of National Labs Day, a career fair featuring 15 national labs, DOE, and NNSA. Held at Howard University in Washington, D.C., the event was designed to introduce science, technology, engineering, and math (STEM) students to the unique career opportunities available at the national laboratories.

The day’s events included panel discussions with representatives from the national labs and DOE, and a showcase of research being conducted at Howard. Students from Howard and neighboring minority-serving institutions (MSIs) were invited, and more than 200 took part.

Event increases visibility of labs among students

“National Labs Day is among the first coordinated steps toward strengthening relationships between the nation’s DOE labs and historically black colleges and universities to foster talent development and acquisition,” says Melonie Parker, VP of Human Resources and Communications Div. 3000.

“This event provided an opportunity for the national labs to showcase the unique capabilities and the importance of complex wide mission programs and deliverables. It also helped us attract and hire the most qualified applicants in STEM fields. Like other technical companies, the nation’s labs are at a pivotal point in addressing growing attrition rates in critical skill areas while ensuring diversity in our workforce, and we are working to extend access and visibility into the work of the national labs to those who may not have it.”

Howard was a natural fit for event

Howard was selected as the site for the first National Labs Day because of its central location, and also because in 2015 it received a grant, along with 12 other MSIs, from the DOE Office of Economic Impact and Diversity to help strengthen the pipeline of students from MSIs to careers in the national laboratories. Howard is also ranked among the nation’s top 150 universities, and second among historically black universities.

In the photo, left to right, are Carl Rhinehart (2993), chair of Sandia’s Black Leadership Committee; Melonie Parker; Chuck Crawley, team supervisor, Custodial Services; Pamelya Herndon, executive director of the Southwood Women’s Law Center; Yvette Kaufman-Bell, director of the Office of African American Affairs; and Dionne Rodgers, president of the Network of Intel African American Employees.

INCREASING ACCESS — Introducing a panel discussion, Div. 3000 VP Melonie Parker said, “Today we’re increasing access and visibility into the national labs, and helping students explore the art of the possible.”

ROLLING OUT — Sandia overview panelists discuss their roles and responsibilities at the labs.

NEW MEXICO AFRICAN AMERICAN COMMUNITY LEADERS

visited Sandia earlier this month to learn about the Labs’ mission and to hear more about its progress in a key outreach objective. “Strengthening the communities where we live and work,” HR and Communications Div. 3000 VP Melonie Parker welcomed the visitors at Sandia’s Center for Global Security and Cooperation. Also greeting the visitors were Carl Rhinehart, manager of Mechanical Design Dept. 2993, and Black Leadership Committee Executive Champion Steve Rottler, deputy Laboratories director and executive VP for National Security Programs, who provided a Sandia overview. Visitors heard about the background, accomplishments, and activities of Sandia’s Black Leadership Committee and an overview of the Labs’ community outreach and employee recruiting programs. Staff members talked about how they were recruited to the Labs and their experiences working at Sandia and living in the community. After the presentations, the group toured a display of homeland security and nonproliferation technologies in the Center for National Security and Arms Control. In the photo, left to right, are Carl Rhinehart (2993), chair of Sandia’s Black Leadership Committee; Rena Bendaw, Grant Chapel AME Church Lay Organization president; James Lewis, retired New Mexico state treasurer; Melonie Parker; Chuck Crawley, team supervisor, Custodial Services; Pamelya Herndon, executive director of the Southwest Women’s Law Center; Yvette Kaufman-Bell, director of the Office of African American Affairs; and Dionne Rodgers, president of the Network of Intel African American Employees.

(Photo by Randy Monroy)