PLANTS AT THE PUMP. . . . PAGE 3

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SandiaLabNews

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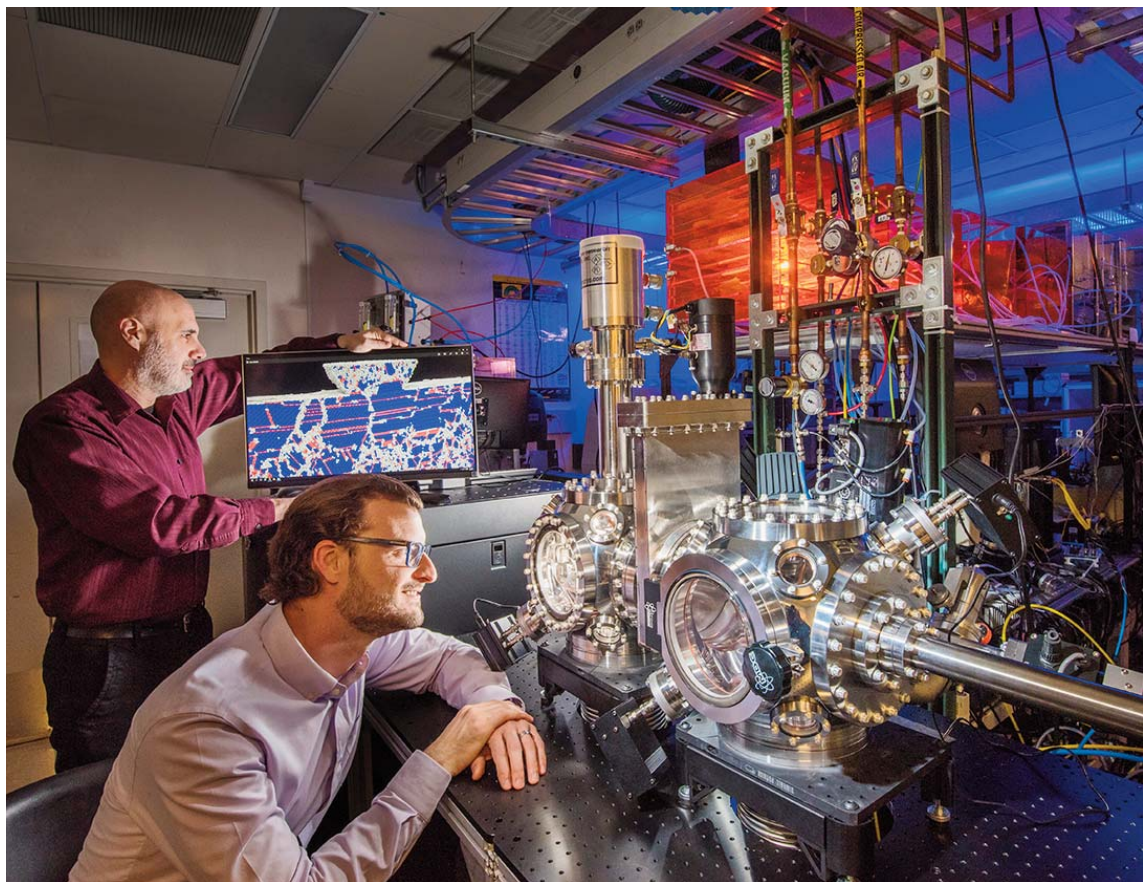
Beating the daily grind



Predicting the limits of friction on metals

By Sue Major Holmes

Normally, bare metal sliding against bare metal is not a good thing. Friction will destroy pistons in an engine, for example, without lubrication.

Sometimes, however, functions require metal on metal contact, such as in headphone jacks or electrical systems in wind turbines. Still, friction causes wear and wear destroys performance, and it's been difficult to predict when that will happen.

Until now.

Sandia materials scientists Nicolas Argibay (1851) and Michael Chandross (1814) and colleagues devel-

(Continued on page 4)

COLLABORATION — Michael Chandross, left, and Nicolas Argibay show a computer simulation and an ultrahigh vacuum tribometer used in friction and wear testing, which are among the tools they use in a collaborative effort that developed a model to predict the friction behavior of metals. The goal is to understand friction and wear of materials at the most fundamental level. Design, development, and construction of the new UHV tribometer was funded by Sandia nuclear weapons groups. (Photo by Randy Montoya)

Shoe Box Challenge
Page 7

Inside . . .

STEM Day at the Labs
Page 12

POWER PARTNERS

Sandia draws industry into quest for cheaper, cleaner electricity

By Nancy Salem

Sandia is working with three industry partners to commercialize a distributed power system that can produce cheaper, cleaner, more efficient electricity.

The Labs signed three-year Cooperative Research and Development Agreements (CRADAs) with Peregrine Turbine Technologies of Wiscasset, Maine; Xdot Engineering and Analysis of Charlottesville, Virginia; and Flowserve Corp. of Irving, Texas.

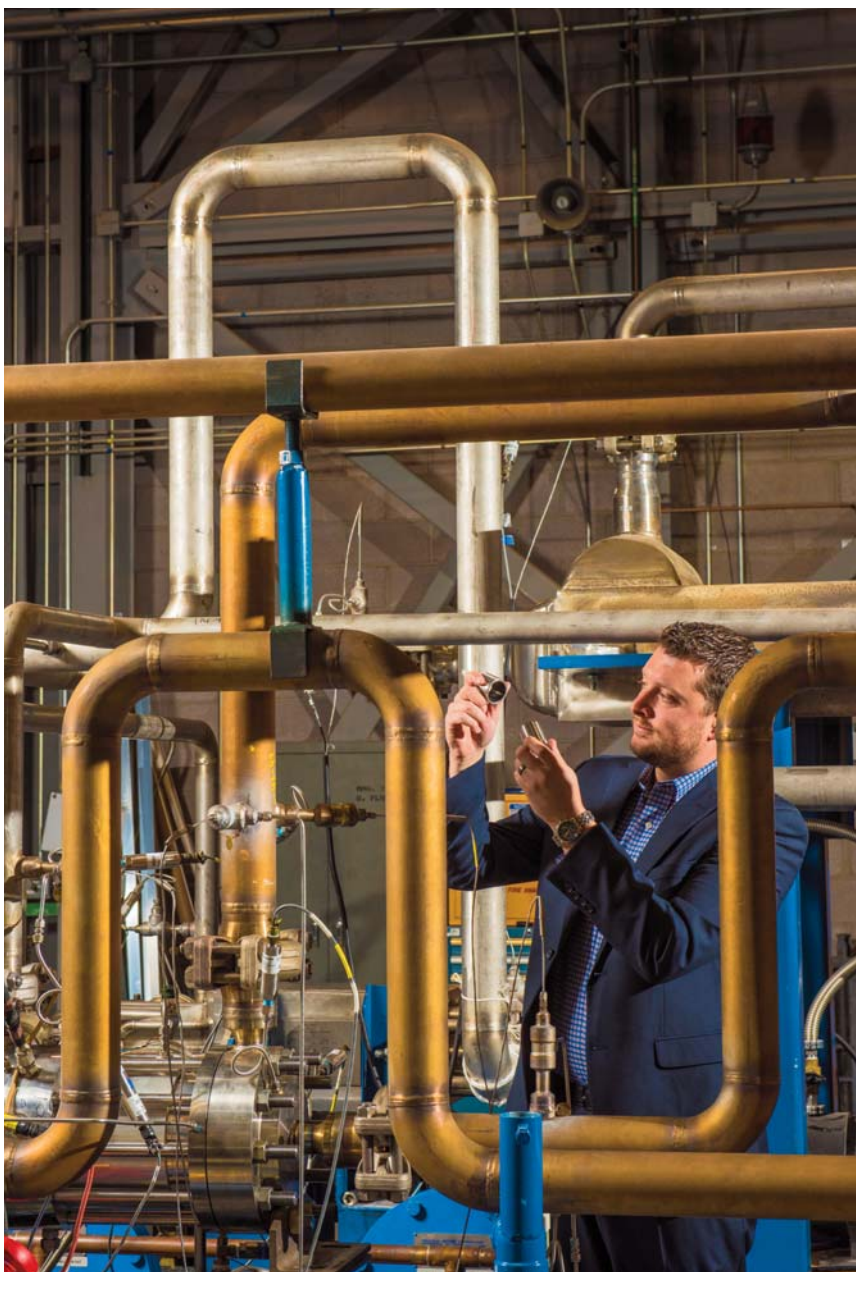
"These CRADAs give us an avenue to engage industry one-on-one for what we need and what they need, and identify a pathway to commercialization of a game-changing technology," says Gary Rochau, manager of Advanced Nuclear Concepts Dept. 6221. "The goal is to double the efficiency of converting heat to electricity without using water and make it economical so it's as cheap as steam."

Sandia is developing supercritical carbon dioxide (S-CO_2) recompression closed Brayton cycle technology, a power generation system that could increase thermal-to-electric conversion efficiency as much as 50 percent over conventional steam technol-

(Continued on page 5)

TEST LOOP — Principal investigator Darryn Fleming is surrounded by the workings of Sandia's 1-megawatt thermal supercritical CO_2 recompression closed Brayton cycle test loop. "High temperature and pressure testing with supercritical CO_2 is complex and testing is expensive and high risk," Darryn says. "We're set up to do multiple large-scale demonstrations that use high temperature and high pressure." (Photo by Randy Montoya)

Brain-inspired cybersecurity. . . . . Page 6



That's that

When Marco Polo, the young Venetian one-percenter, returned from his epic 24-year journey to China in the 13th century, his exploits were recorded in the form of a travelogue called *The Book of the Marvels of the World*, which we know better as *The Travels of Marco Polo*.

The book caused a sensation in Europe, recounting as it did young Marco's adventures in a great civilization that was virtually unknown to the West. Many were swept up by the romance of it all, but some readers of a skeptical bent felt the book was more fantasy than fact; indeed, powerful figures in what we might today call "the establishment" accused Polo outright of making it all up. Marco, however, insisted right up until the day he died that it was all true, every word. And more! It is said that upon his deathbed, Marco was given one last chance to recant his story so that he might enter his afterlife with a clean bill of health. To those demands he replied, "I haven't told the half of what I saw!"

I've thought about Marco Polo and that haunting comment of his many times over the years, particularly when we publish our annual *Labs Accomplishments* issue, which will come out later this month in lieu of our regular March 31 *Lab News*.

The *Labs Accomplishments* issue, like Marco Polo's *The Book of the Marvels of the World*, takes us on a journey to some unlikely, often remarkable places. Behind the brief items in *Accomplishments* — each submission was limited by necessity to less than 100 words — are untold tales of high adventure, disappointments, setbacks, persistence, inspiration, serendipity, and triumph. And it's not too much, I think, to say that the accomplishments submissions are often — more often than not, probably — love stories. Yes, for who could accomplish the breakthroughs, the milestones, the advances, without a deep love for the very process of discovery, a love of the quest for knowledge, a love not just for the work but for the greater mission?

And *Labs Accomplishments* is like Marco Polo's book for another reason: We haven't told the half of it. So much of what we do — understandably — can never be discussed in open forums. Some of our most remarkable work goes unsung by the public; often, the individuals involved can't even share the details of their work with their families. That's a real sacrifice. One of our deepest, most innate desires is to share the most important things in our lives with those we love. To sublimate that desire is no easy thing to do and no small thing to ask of any man or woman. The folks whose work we can't write about and show you in the *Lab News* and in the *Labs Accomplishments* are heroes in my book, heroes who pay a price every day for the chance to serve the nation.

* * *

The US Senate has confirmed former Texas governor Rick Perry as our new Secretary of Energy. In an all-hands meeting introducing himself to the DOE family, Perry had high praise for the work of the laboratories and expressed genuine excitement at the prospect of leading the agency, citing the many areas in which it can make the world a better place for all. He concluded his remarks on a weighty note.

"When you look at this very difficult world we live in," he said, "what this agency does on the side of nuclear energy and the arsenal that you oversee, it's a sobering moment as well.

"On the one side [there is] what this agency does relative to the labs and to the opportunities in commercialization and the next big thing and ideas that most people in the world haven't even dreamt of. And on the other side we have this extraordinary responsibility of the safety and modernization of an arsenal that has the potential to be as devastating as anything the world has ever seen. And that responsibility, both in keeping it safe and in modernizing it and obviously of cleaning up after the Cold War, is a really, really powerful responsibility, one that we all understand the importance of and that we take with great and extraordinary seriousness."

Perry concluded back on a high note, saying, "I'm proud to be an American every day, but today I am truly blessed and as proud as I have ever been to say that I am on a team of men and women who have the potential to change the world."

See you next time.

— *Bill Murphy (MS 1468, 505-845-0845, wtmurph@sandia.gov)*

Retiree deaths

Murl Moore (age 84) . . . . . Oct. 8
M. Ann Freudendahl (74). . . . . Oct. 11
Suzanna Bemis (55). . . . . Oct. 17
R. Stanley Howard (91). . . . . Oct. 22
James Pennington (86). . . . . Dec. 11
Felix Almaraz (87). . . . . Dec. 12
R. Denise Reed (66). . . . . Dec. 15
Norma Adams (82). . . . . Dec. 20
Nigel Hey (80). . . . . Dec. 21
E. Leora Vandevender (72). . . . . Dec. 23
Dolores Sanchez-McGlotten (74). . . . . Dec. 24
Owen Berg (82). . . . . Dec. 26
John Sisneros (84). . . . . Dec. 27
Henry Pacheco (87). . . . . Dec. 28
Juanita Otero (89). . . . . Dec. 30
Frances Grosshans (90). . . . . Dec. 30
Brenda Rinaldi (50). . . . . Jan. 4
Harry Olson (93). . . . . Jan. 7
William Shurtleff (74). . . . . Jan. 8
Barry Marder (74). . . . . Jan. 10
Sandra Wagner (64). . . . . Jan. 10
Robert Poole (74). . . . . Jan. 11
Catharine Sifford (65). . . . . Jan. 13
Harold Linker (88). . . . . Jan. 14
Paul Lemke (76). . . . . Jan. 17
Samuel Lucero (56). . . . . Jan. 18
G. Vaughan (90). . . . . Jan. 20
Trevor Looney (86). . . . . Jan. 20
Dale Shenk (78). . . . . Jan. 23
Christine White (63). . . . . Jan. 24
Adalbert Smiel (80). . . . . Jan. 24
Sieglinde Neuhauser (69). . . . . Jan. 25
Darrell Breehl (94). . . . . Jan. 25
W. Irene Burand (76). . . . . Jan. 25
Clifford Condit (77). . . . . Jan. 26
Jimmy Aldaz (68). . . . . Jan. 27
Arnold Colin Lamb (93). . . . . Jan. 28
Eloy Garley (69). . . . . Jan. 28
Nell Arnett (96). . . . . Feb. 8
Richard Spalding (84). . . . . Feb. 8
Yolanda Griego (58). . . . . Feb. 10
Lee Dubes (65). . . . . Feb. 10

Recent Patents

James E. Martin (1124) and Kyle Jameson Solis (1354): Magnetic Method for Stimulating Transport in Fluids. Patent No. 9,470,458.

Hung Loui (5345): Method of Achieving Ultra-Wideband True-Time-Delay Beam Steering for Active Electronically Scanned Arrays. Patent No. 9,479,232.

Timothy J. Boyle (1815) and Bernadette A. Hernandez-Sanchez (1815): Method to Synthesize Metal Chalcogenide Monolayer Nanomaterials. Patent No. 9,517,937.

Jason Hamlet (5627): Method, Apparatus and System to Compensate for Drift by Physically Unclonable Function Circuitry. Patent No. 9,501,664.

Todd Bauer (1746): Methods for Dry Etching Semiconductor Devices. Patent No. 9,484,216.

Darren W. Branch (8634): Miniature Acoustic Wave Lysis System and Uses Thereof. Patent No. 9,512,421.

Scott E. Bisson (8128) and Daniel Beom Soo Soh (8128): On-Chip Entangled Photon Source. Patent No. 9,500,930.

See more patents on page 11.

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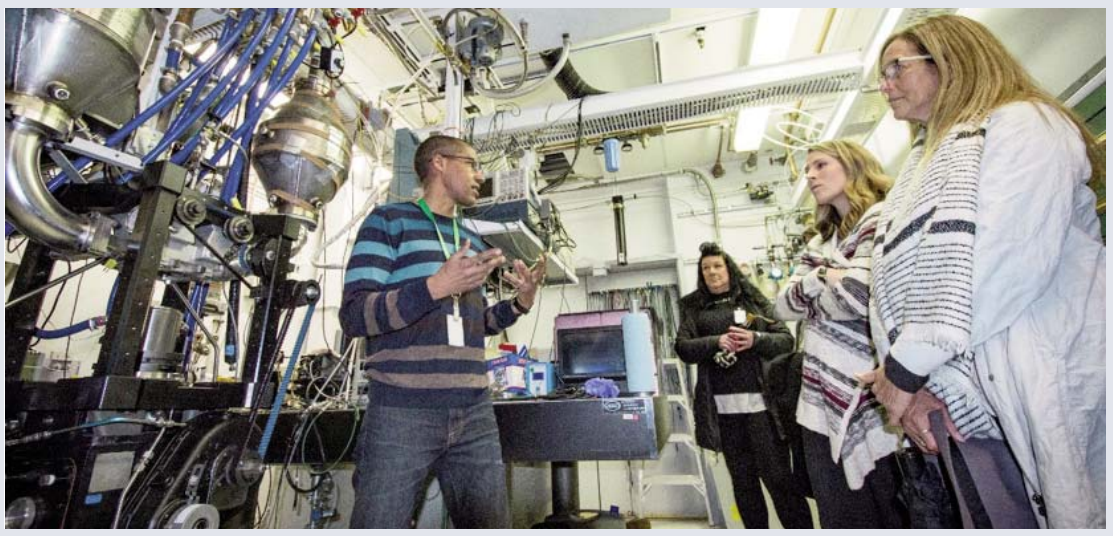
LOCKHEED MARTIN

Leadership Livermore group tours California lab



PARTNERSHIPS OFFICER Stephanie Beasly hosted women from Leadership Livermore on a Feb. 21 tour of Sandia/California. Leadership Livermore, a nine-month program hosted by the Livermore Chamber of Commerce in partnership with the city of Livermore, strengthens ties between local institutions and business executives. Tour participants learned about Sandia's history and current national security missions, and explored the Livermore Valley Open Campus area. The day included a presentation on Sandia-developed modeling tools that allow government agencies to plan for high-consequence threats such as earthquakes, floods, and fires. In the photo above, researcher Isaac Ekoto (8362) shows the group his newly renovated advanced automotive combustion laboratory in the Combustion Research Facility. (Photo by Loren Stacks)

Plants at the pump

Sandia seeks toughest strains of algae for biofuel production as part of multilab project

By Jules Bernstein

Regular, unleaded, or algae?

That's a choice drivers could make at the pump one day. But for algal biofuels to compete with petroleum, farming algae has to become less expensive. Toward that goal, Sandia is testing strains of algae for resistance to a host of predators and diseases, and learning to detect when an algae pond is about to crash.

These experiments are part of the new, $6 million Development of Integrated Screening, Cultivar Optimization and Validation Research (DISCOVR) project, whose goal is to determine which algae strains are the toughest and most commercially viable.

ALGAE ABUSE – Sandia biochemist Carolyn Fisher (8623) examines a beaker full of microscopic algae eaters called rotifers being grown for the DISCOVR project. (Photo by Dino Vournas)

DOE's Office of Energy Efficiency and Renewable Energy sponsors the project, and Sandia's partners are Los Alamos (LANL) and Pacific Northwest (PNNL) national laboratories, the National Renewable Energy Laboratory (NREL), and Arizona State University (ASU).

Algae is a desirable biofuel source because it doesn't compete with other plants that serve as sources of food. However, an estimated 30 percent of current production on algae farms is lost each year due to pond crashes.

The national labs, and Sandia in particular with its expertise on algae predators, are uniquely suited for this research. Sandia is using its 1,000-liter indoor algae raceway facility, also called a "crash lab," to perform experiments that industrial groups will not do because they can't afford to contaminate their ponds.

"We use organisms and agents that many of my industrial partners do not allow on their sites," says biologist Todd Lane (8623), Sandia's project lead. "They cannot culture these creatures in their own facilities. It's too much of a risk."

Assembling 'a diverse panel of nasty things'

Todd and his team are cultivating what he calls "a diverse panel of nasty things" to learn which type of parasitic fungus, bacterium, or disease kills various strains of algae the quickest.

Perhaps the most threatening member of the predatory panel is a rotifer, a microscopic organism capable of eating 200 algal cells per minute. Rotifer infection can take a 132,000-gallon commercial pond from a healthy green to collapse within 48 hours. "They are basically tiny vacuums for algae," says Todd.

This algae abuse will begin in March, using a strain called nanochloropsis as a baseline for survival statistics. Ironically, nanochloropsis is an industrial algae strain typically grown for feeding rotifers on fish farms. The team will conduct these tests on 15 algae strains in the crash lab under light and temperature conditions that mimic a variety of outdoor environments.

The ability to simulate different climates further enhances the team's ability to validate certain strains. However, even the strongest algae are susceptible to infections, so detecting infections before ponds crash is key.

Reflected light can indicate pathogen presence

For early crash detection, Jeri Timlin (8631), an analytical chemist on Sandia's DISCOVR team, is using a technique called spectro-radiometric monitoring to watch the ponds for subtle changes in reflected light that indicate the presence of pathogens or predators. Sandia researcher Tom Reichardt (8128), a project adviser, developed the technique. Most objects reflect light in different wavelengths, which result in the perception of color. This technique can detect subtle color changes as well as other physical and chemical properties of the algae, making it possible to determine the pond's density and overall health.

A major advantage of the Sandia monitoring method is that it provides real-time measurements without lab analysis. Previously, scientists had to do the time-consuming task of taking a sample from a pond back to a lab to measure it. Spectro-radiometric monitoring takes precise pond measurements every five minutes, without physical contact with the pond itself. And, no human is needed to make the measurements.

Algae pipeline to economic competitiveness

While Sandia monitors ponds and evaluates resistance to diseases, PNNL will quantify the biomass production rate of 10 strains of algae that they grow in a variety of simulated environmental conditions. NREL then will perform compositional analysis on the same strains, seeking those best suited for fuel production.

TINY PREDATOR – Microscope photo of a rotifer grown at Sandia National Laboratories shows a belly full of algae. (Image provided by Sandia)

Later phases of the three-year project will involve partners in this "algae pipeline," increasing pond culture stability and evaluating the potential for generating products other than fuel, such as chemicals used for industrial purposes. LANL will take the strongest strains and work to improve them further, aiming for faster growth rates and higher tolerance for a range of environmental conditions. Finally, ASU will validate the national labs' research in outdoor test beds.

By determining the most resilient algae strains and best practices for algae farming, Sandia and its partner labs may one day enable farmers to produce enough algae to make biofuels a real competitor at the pump.

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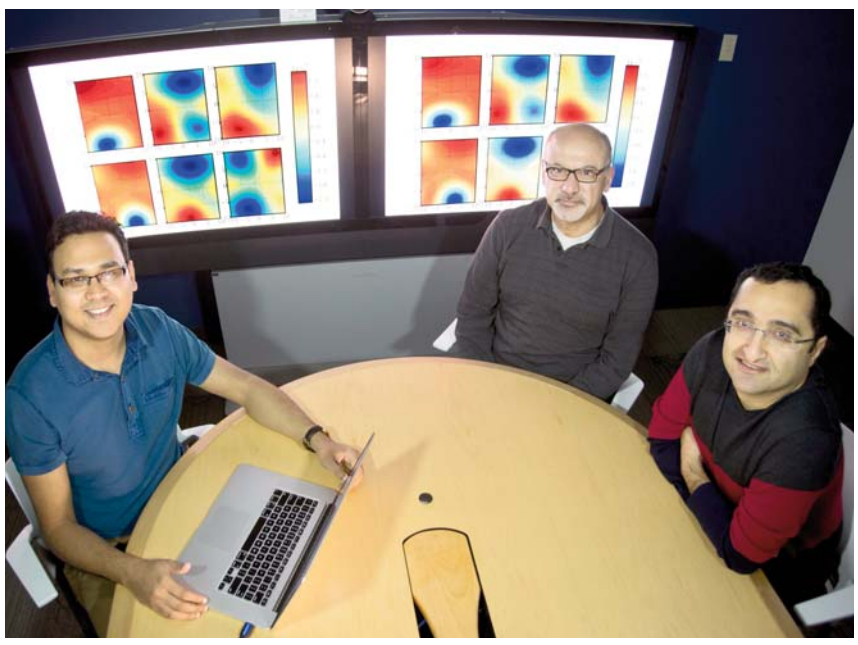
Reversing the curse

Sandia researchers develop mathematical methods to improve computational efficiency in quantum chemistry



SANDIA RESEARCHERS Prashant Rai, Khachik Sargsyan, and Habib Najm.

By Michael Padilla

Sandia researchers have developed new mathematical techniques that can be used to study the behavior of large molecules at quantum scale. This technology helps reduce computation time and improves the predictive capability of theoretical chemistry models.

Sandia postdoctoral researcher Prashant Rai, working with Khachik Sargsyan and Habib Najm (all 8351) at the Combustion Research Facility (CRF), in collaboration with quantum chemists So Hirata and Matthew Hermes from the University of Illinois at Urbana-Champaign, developed computationally efficient methods to approximate potential energy surfaces of molecules by probing them at fewer configurations as compared to classical methods. Understanding potential energy surfaces, key elements in virtually all calculations in quantum dynamics, is required to accurately estimate the energy and frequency of vibrational modes of molecules.

The initial, promising results of this research will be published in *Molecular Physics* in an article titled "Low-rank canonical-tensor decomposition of potential energy surfaces: Application to grid-based diagrammatic vibrational Green's function theory."

"Approximating potential energy surfaces of bigger molecules is an extremely challenging task due to the exponential increase in information required to describe them with each additional atom in the system," Prashant says. "In mathematics, it is termed the Curse of Dimensionality."

The key to beating the Curse of Dimensionality is to exploit the characteristics of the specific structure of the potential energy surfaces. Knowledge of this structure can then be used to approximate the requisite high dimensional functions.

"We make use of the fact that although potential energy surfaces can be high-dimensional, they can be well-approximated as a small sum of products of one-dimensional functions. This is known as the low rank structure where the rank of the potential energy surface is the number of terms in the sum," Prashant says. "Such an assumption on structure is quite general and has also been used in similar problems in other fields. Mathematically, the intuition of low rank approximation techniques comes from multilinear algebra where the function is interpreted as a tensor and is decomposed using standard tensor decomposition techniques."

Energy and frequency corrections to classical results are formulated as integrals of these high-dimensional functions. Approximation in such a low rank format renders these functions easily integrable as it breaks the integration problem to the sum of products of one or two dimensional integrals for which standard integration methods apply.

This method has been initially applied and tested on small molecules such as water and formaldehyde. When compared to the classical Monte Carlo method, a standard workhorse for high dimensional integration problems, this approach improves the computational efficiency by orders of magnitude with better accuracy at the same time. Rai said the next step in this study is to further enhance the technique by challenging it with bigger molecules such as benzene.

Interdisciplinary studies such as these provide opportunities for cross pollination of ideas, thereby providing a new perspective on problems and their possible solutions. In the context of combustion research at the CRF, this work advances the computational capabilities available for the detailed study of complex hydrocarbon molecules relevant in engine combustion.

Friction

(Continued from page 1)

oped a model to predict the limits of friction behavior of metals based on materials properties — how hard you can push on materials or how much current you can put through them before they stop working properly. They've presented their results at invited talks, most recently the 2016 Gordon Research Conference on Tribology, and in peer-reviewed papers, including a recent article in the *Journal of Materials Science*.

Their model could change the world of electrical contacts, affecting industries from electric vehicles to wind turbines. Understanding the fundamental causes of failure in metal contacts allows engineers to step in and fix the problem, and potentially lights up more paths toward new materials designs.

Linking science, engineering applications

"It's a tool to do design and it's a tool to do science," Nicolas says. "It's really that link between fundamental science and engineering applications."

The discovery of how to predict the friction behavior of metals began as a study of specific materials for projects.

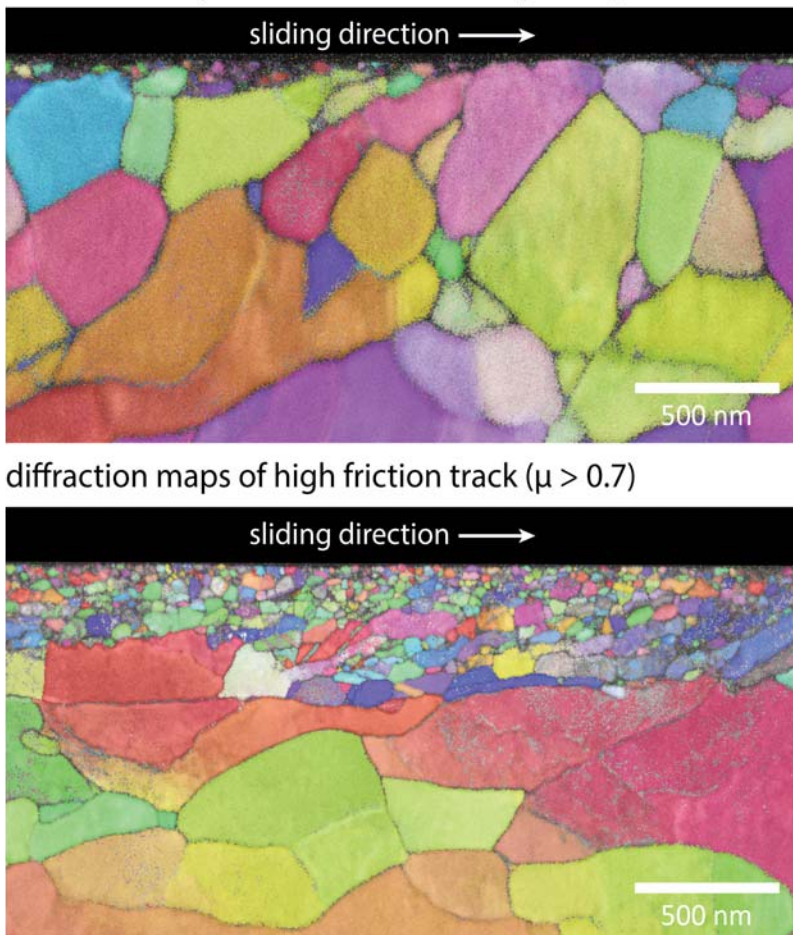
"It's a moment where you go from just having to say, 'The materials behavior will be this because we measured it in those conditions' to saying, 'I can tell you what conditions you can run in and get the behavior you want,'" Nicolas says. "In fact, we provide guidelines for developing new materials."

Designers choose materials based on engineering rules of thumb under certain operating conditions, using the conventional wisdom that harder materials create less friction.

But Sandia's research demonstrates the stability of the microstructure governs the friction behavior engineers care about, and that changes how engineers can think about design when they characterize and select materials, the researchers say.

The team studied pure metals, such as gold and copper, to break down the friction problem by looking at the simplest systems. Once they understood the fundamental behavior of pure metals, they say, it was easier to demonstrate that these ideas apply to more complex structures and more complex materials.

The idea developed in a convoluted fashion, starting several years ago when Michael was asked for simulations to help improve hard gold coatings — soft gold with a minor amount of another metal to make it harder. Gold is an efficient, corrosion-resistant conductor, but generally has high adhesion and friction — and thus high wear.



ONE SMALL DIFFERENCE in grain size equals one giant change in friction. These two electron transmission Kikuchi diffraction maps show that a relatively subtle difference in surface grain size means a very large change in friction. The work is part of a Sandia collaboration that links science to engineering applications in the study of friction. (Image courtesy of Center 1800)

That project produced a paper that excited Nicolas, who told Michael he could do experiments to prove the concepts the paper described.

"From those experiments, the whole thing exploded," Michael says.

"We looked at the pure metals as a way to validate some of the hypotheses we had from Mike's analysis of more complex systems," Nicolas says. "If these ideas work in more complex systems, they ought to work in the most difficult scenario, the least likely scenario conventionally, and they did."

Sandia's work has implications for the growing worlds of wind turbines and electric vehicles, where companies seek an edge over the competition. The demand for electric cars and alternative ways of making electricity are likely to expand, creating demand for new technologies.

Nicolas is helping design and develop a prototype rotary electrical contact for wind turbines in a Laboratory Directed Research and Development (LDRD) project led by Wayne Staats (8366). The initial concept came out of an earlier LDRD project led by Jeff Koplow (8366).

"Basically we're bringing back technologies that were discarded because they didn't really understand the materials and couldn't make them work where and how they wanted to," he says.

New projects ongoing

The project is exploring copper against a copper alloy for a high-performance, efficient electrical contact. That could allow the wind turbine industry to explore designs that weren't possible before.

In addition, the electrical contacts industry, which now uses alternating current in devices, might finally be able to turn to direct current devices as higher-performance alternatives. As a possible interim step, Sandia researchers are exploring metallic electrical contacts as a drop-in for some applications, avoiding major changes in how the devices work.

If they demonstrate the theory is sound, then engineers can change how they think about the fundamentals of design in some of these devices, they say.

Follow-up funding allowed the team to study the variable of temperature, and now Michael has begun an LDRD project to look at metals with other structures. Previous work has been done with face-centered cubic structured metals. His project seeks to understand friction in body-centered cubic metals, BCC metals, most commonly used for structural purposes. Researchers are looking at iron and tantalum.

Conventional wisdom holds that BCC metals won't produce low friction. "This is one of those instances where understanding the molecular scale or atomic scale mechanisms caused us to say, 'Yes, but they're bad only if you're not in the right conditions.' What happens when you are in the right conditions?" Michael says.

BCC metals could open up more design and engineering possibilities for wind power generation and electric vehicles, improving efficiency and ultimately reducing maintenance and manufacturing costs.

Pure serendipity led to discovery

Sandia researchers who came up with a model to predict the limits of friction behavior in metals are "happily defying conventional wisdom and a hundred years of publications," Nicolas Argibay says. Those publications include a seminal paper from the 1930s in *Nature* that basically states pure metals have high friction and therefore are terrible for all kinds of uses.

Over the next 80 years, there were sporadic reports of experiments that showed low friction in pure metals "but they reported it as a curiosity, something strange that happened," says Nicolas' colleague, Michael Chandross. "They mentioned it one sentence in a paper, no explanation of why, no looking at it, just saying, 'Yeah, this happened sometimes, that's weird.'"

In the course of looking up a paper for their study, Michael (1814) and Nicolas (1851) stumbled across another paper about low friction in pure metals. It was pure serendipity that the end of the second paper was photocopied with the beginning of the paper they had sought. "I looked at Mike like, 'We've got to find that paper!'" Nicolas recalls.

"When we pulled that paper and read it, sure enough, it was conditions that we now understand why they worked. They happened to hit conditions that were right on the cusp of what we reproducibly have done – and can now explain," he says.

ISEE honors retired Sandia explosives engineer Dale Preece

By Sue Major Holmes

The International Society of Explosives Engineers (ISEE) has awarded Sandia retiree Dale Preece the society's 2017 Distinguished Service Award, given for outstanding contributions to the field of explosives engineering.

He received the award at the society's 43rd awards and recognition banquet Jan. 31 in Orlando, Florida. The award "was a surprise, but a pleasant one," he says.

"I've been very privileged to have spent my career associated with the very best people on the planet," Preece says. "This award reminds me of that cherished association."

Preece joined Sandia in 1980 and worked on a wide variety of rock mechanics-related proj-ects, including ones for the Strategic Petroleum Reserve, the Waste Isolation Pilot Project, Yucca Mountain, and sand production in oil wells. He worked for a number of years in Sandia's Explosive Applications department, now Explosives Engineering Operations Dept. 6649, designing and testing various explosive devices.

In 1986, he began a 17-year contracting relationship with Atlas Powder Co., predecessor to Orica USA Inc., to develop computer modeling methods to predict the results of rock blasting. That work resulted in the computer programs DMC, for Distinct Motion Code, and DMC-3D, which are used to predict rock movement, or heave, from blasting.

RETIRED SANDIA EXPLOSIVES ENGINEER Dale Preece, left, accepts the International Society of Explosives Engineers' 2017 Distinguished Service Award from Jack Eloranta, president of the society. Preece retired from Sandia in 2007 after a 27-year career at the Labs. (Photo courtesy of ISEE)

Long-time contributor to ISEE

Preece retired from Sandia in 2007 as a distinguished member of the technical staff, and joined Orica Mining Services as a senior researcher and research manager. There he continued to work with Sandia's Computer Science Research Institute (CSRI) under a contract between Orica and Sandia. Orica chose Stewart Silling at CSRI to convert the DMC-3D to parallel processing, work that was completed in 2015.

Preece is the author of 135 technical papers and journal articles and has contributed to several books, including the latest ISEE Blasters Handbook. He is also an editor of the ISEE's *Blasting and Fragmentation Journal*.

Preece, who now lives in Saratoga Springs, Utah, has attended and contributed to every annual ISEE conference since 1988. He also helped charter two new ISEE chapters, the New Mexico Rio Grande chapter in 2001 and the Intermountain West chapter this year.

ISEE was founded in 1974 to advance the science and art of explosives engineering to help the blaster in the field. Today it brings together more than 4,000 professionals from around the world and has 43 local chapters.

Brayton CRADA

(Continued from page 1)

ogy. Brayton cycle, named after 19th century mechanical engineer George Brayton, originally worked by heating air in a confined space and releasing it to generate shaft power or thrust, like a jet engine.

Sandia's Brayton cycle uses S-CO_2, which is chemically stable, reliable, low cost, non-toxic, non-flammable, and readily available, as the working fluid. "It's basically a jet engine running in a closed loop with S-CO_2 as the working fluid," says Darryn Fleming (6221), principal investigator for Advanced Reactor Technology in DOE's Supercritical Transformational Electric Power program.

Sandia has been testing various components, bearings, seals, and heat exchangers near or exceeding the critical point where carbon dioxide has the density close to a liquid but many properties of a gas. Tests showed several elements of the system were at a low technical readiness level, or TRL, a measure of technology maturity. "To get this to market, we needed to increase the TRL of numerous components and procedures, three of which are seals, bearings, and heat exchangers," Darryn says.

Sandia posted Federal Business Opportunities ads seeking industrial partners, and Peregrine, Xdot, and Flowserve were among multiple respondents.

Challenging environment for components

Peregrine is working with Sandia on a thermally compliant heat exchanger that can handle the Brayton cycle's rigorous thermal stresses. "We took our expertise in the design of turbo machinery hot sections and applied it to heat exchanger design to mitigate the damage normally caused by large temperature swings," says Peregrine President David Stapp. "This design will open the door to cost-effective heat exchangers that can meet customer requirements in commercial applications."

Xdot is developing a foil bearing that supports a turbine shaft spinning at high speed in S-CO_2. "Ball bearings don't work well in the S-CO_2 environment," says Xdot founder Erik Swanson. "We have a foil bearing that can be directly lubricated by S-CO_2 with better performance at lower cost — a better mousetrap."

Flowserve's high-intensity seal for power turbines is designed to hold tight with S-CO_2 going into the turbine at 700 degrees C and 4,400 pounds per square inch, or psi. "That is super high temperature, super high pressure," Darryn says. "Seals can be leaky. We need a seal that won't bleed out and send CO_2 into the atmosphere."

> *"We took our expertise in the design of turbo machinery hot sections and applied it to heat exchanger design to mitigate the damage normally caused by large temperature swings."*
>
> **— Peregrine President David Strapp**

Lionel Young, director of advanced technology for Flowserve, says his company started from scratch on a seal to perform in S-CO_2. "Although the high pressure and speeds for this application are not new for Flowserve, such a seal hadn't been designed for these extreme temperatures," he says. "The critical part has been the design of the secondary dynamic gasket. The seal for the most part relies on conventional technology but the dynamic gasket, which must be able to slide and seal, has to be able to work at these extreme pressures and temperatures without leakage."

Ability to test at high temperature and pressure

Sandia offers its partners a 1-megawatt thermal S-CO_2 recompression closed Brayton cycle test loop that can run dynamic tests along with dedicated test rigs for bearings and seals. "We help them test their technologies to prove they work with supercritical CO_2. They have the expertise but not the testing ability. Going to temperatures and pressures that far exceed typical metals is not trivial," Darryn says. "High temperature and pressure testing with supercritical CO_2 is complex and testing is expensive and high risk. We're set up to do multiple large-scale demonstrations that use high temperature and high pressure. It helps get their products out to market faster and with less risk."

All three companies have made strides and developed prototypes with Sandia's technical input and testing made possible by the CRADAs, agreements between a government agency and a private company or university to work together on research and development.

"It's been great to work with a national lab," Swanson says. "They have incredible resources. We're sharing our technology and as the program goes on we look forward to the test data for this challenging application."

Young says Flowserve has limited ability to test at the temperature requirements of S-CO_2 Brayton cycle. "While Flowserve will test a prototype at full pressure and speed, but at a lower temperature, we will depend on Sandia to test to full temperature," he says. "The collaboration between our team and Darryn and his team has been excellent. They are open and helpful and we believe the result will be to help advance seal technology."

Stapp says being teamed with Sandia's experts has been invaluable. "I couldn't be happier," he says.

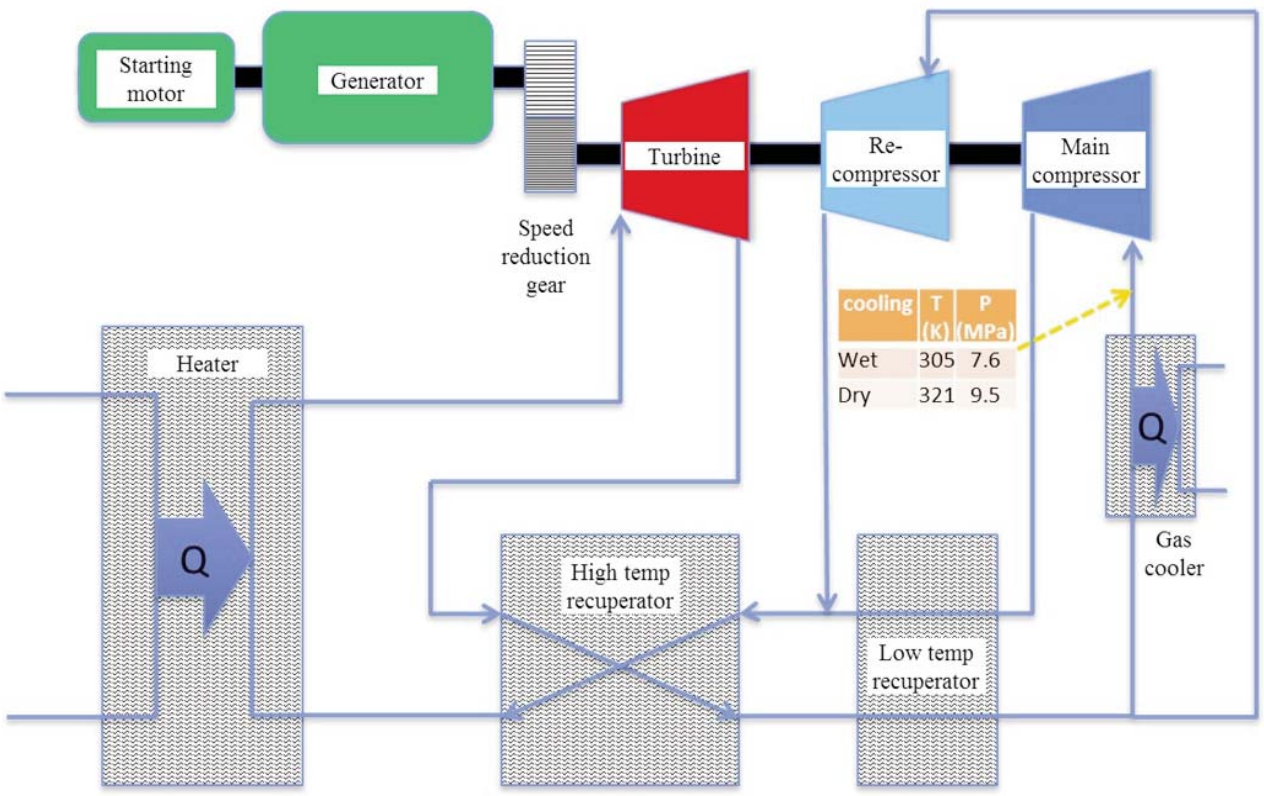
Aiming for a 10-megawatt demonstration

The goal of Sandia and DOE is to have a 10-megawatt commercially demonstrated S-CO_2 Brayton cycle at the Labs by 2020. "It's now time to take this technology and build test rigs," Darryn says. "A 10 megawatt electric demonstration needs to be made. That's where the commercial entities get excited. They're not interested in small laboratory units. We need a commercially scalable system."

The Brayton technology can use solar, biofuels, and natural gas to produce electricity for the distributed energy market, Gary says. Distributed electrical generation is the production of power at or near point of use versus at a large-scale, central generation location requiring long-distance transmission and local distribution. The cost of transmission and distribution typically accounts for half the cost of delivered electricity.

Gary says Sandia is working through the three CRADAs with manufacturers who will bring Brayton technology to market, US produced, manufactured and exportable. "We're helping them and they're helping us," he says. "If they see the market and we have the science, we're getting the engineering done so they can hit the market, and that cranks everything up. We don't want a novelty that nobody can use."

What's in a power cycle?



BRAYTON CYCLE — The illustration shows a recompression closed Brayton cycle with arrows indicating the flow of supercritical carbon-dioxide (S-CO_2). Starting at the lower left corner, S-CO_2 is heated then sent through a turbine where energy is extracted. It then goes through recuperators, also called heat exchangers, where the hot S-CO_2 transfers heat to the colder S-CO_2. The S-CO_2 flow is then split between the compressor and re-compressor and redistributed back into the system.

Most electricity produced around the world uses a general closed-loop cycle that pressurizes a fluid, heats it so it has a lot of expansion capability, then blows it through a turbine that operates a generator. The low-pressure fluid exits the turbine, is condensed by removing heat, pressurized again, and reused in the cycle.

The most common cycle, Rankine, boils pressurized water to create steam, which is then expanded through the turbine. The cycle efficiency is about 33 percent — that is, 33 percent of the thermal energy delivered to the fluid is converted into electricity.

Sandia's Brayton cycle uses supercritical carbon dioxide (S-CO_2) as the working fluid, instead of steam, increasing conversion efficiency up to 50 percent, says Darryn Fleming (6221). S-CO_2 is a fluid state of carbon dioxide where it is held above its critical pressure and critical temperature, causing the gas to go beyond liquid or gas into a phase where it acts as both simultaneously.

"One percent of efficiency in a power plant in today's market translates into millions and millions of dollars because less fuel is burned to make the same amount of electricity," Darryn says. "A one-percent improvement in efficiency also reduces greenhouse gases by about 2.9 percent. Increasing efficiency to 50 percent reduces emissions by 34 percent. Consumer costs will decline as efficiency improves and fewer natural resources are consumed."

The reason for higher efficiency is that a sensible temperature difference between the hot turbine discharge and the cold compressor discharge drives heat transfer within the cycle, which provides the vast majority of the heat addition to the high-pressure fluid. The heat rejected while condensing steam at constant temperature in a Rankine cycle is avoided.

While the process of internal heat recuperation applies to any gaseous working fluid, S-CO_2 remains relatively incompressible and dense at normal atmospheric temperatures so the low-temperature condition in the cycle that minimizes the work of compression is easily and cheaply achieved, Darryn says.

Brayton cycle turbines would typically be used for bulk thermal and nuclear generation of electricity, including next-generation power reactors. The goal is to replace steam-driven Rankine cycle turbines, which have lower efficiency, are corrosive at high temperature, and occupy 30 times as much space because of the need for very large turbines and condensers to dispose of excess steam.

There is a lot of industrial and scientific interest in S-CO_2 systems for power generation because they can use any heat source including solar, geothermal, fossil fuel, biofuel, and nuclear. "An ideal place to put a solar plant is in the desert, but there's no water," Darryn says. "Our Brayton cycle is fuel agnostic. You can use nuclear, fossil, renewables. You can use any type of heat source without the use of water because of dry heat rejection."

— Nancy Salem

Bad Apples

New brain-inspired cybersecurity system detects 'malicious players' 100 times faster

BRAIN POWER — Sandia researchers Roger Suppona, left, and John Naegle, and Lewis Rhodes Labs CEO David Follett, at right, examine their Neuromorphic Cyber Microscope. This small processor can replace racks of conventional cybersecurity systems. (Photo by Randy Montoya)

By Mollie Rappe

Cybersecurity is critical — for national security, corporations, and private individuals.

Sophisticated cybersecurity systems excel at finding "bad apples" in computer networks, but they lack the computing power to identify the threats directly.

Instead, they look for general indicators of an attack; call them "apples." Or the system flags very specific patterns, such as "bad Granny Smith apples" or "bad Red Delicious apples."

These limits make it easy for new species of "bad apples" to evade modern cybersecurity systems. And security analysts must sort the real dangers from false alarms such as the nonsense phrase "forbad applesauce."

The Neuromorphic Cyber Microscope, designed by Lewis Rhodes Labs and then improved in partnership with Sandia, directly addresses these limitations. Due to its brain-inspired design, it can look for the complex patterns that indicate "bad apples," all while using less electricity than a standard 60-watt light bulb.

From cerebral palsy to a cybersecurity system

The processor in the Neuromorphic Cyber Microscope is based on the neuroscience research of Dr. Pamela Follett, a co-founder of Lewis Rhodes Labs. Follett is a pediatric neurologist and neuroscientist who studies developmental diseases such as cerebral palsy in children. Her husband, David Follett, co-founder and CEO of Lewis Rhodes Labs, used her work as the basis for a computational model of how the brain processes information.

Comparing brains with cerebral palsy to healthy brains was key to the deeper insights. The Folletts built brain-inspired computer hardware — hardware they knew had the horsepower to solve some real-world problems. Enter Sandia, with a long history of solving real-world challenges.

A team led by computer systems expert John Naegle (9336) sought problems where the neuromorphic processor would excel. The team looked at robotics and pattern recognition before settling on cybersecurity.

"We quickly realized that we could use this architecture to greatly accelerate our ability to look for patterns and even look for complex versions of these patterns," says John.

Brain-inspiration leads to faster, more efficient threat detection

Both the Neuromorphic Cyber Microscope and the human brain continually scan for threats. A hose or stick can cause you to jump, even if you're not searching for a snake. Similarly, the Neuromorphic Cyber Microscope compares streaming data to suspicious patterns in a time-dependent manner. In contrast, conventional cyberdetection systems sequentially match small chunks of data against a library of "bad apple" patterns, which is less efficient, says John.

Sandia tested the Neuromorphic Cyber Microscope on its cybertraffic in a demonstration environment. As the "bad apple" patterns got more complex, the state-of-the-art conventional system slowed exponentially, but the Neuromorphic Cyber Microscope kept performing efficiently, says Roger Suppona (9317), a cybersecurity expert at Sandia. In fact, it's more than 100 times faster and 1,000 times more energy-efficient than racks of conventional cybersecurity systems. "This completely changes the way that we look for suspicious activity without running the risk of overwhelming our analysts with too much information," says Roger.

The Neuromorphic Cyber Microscope, an R&D100 Awards finalist this year, is in the early stages of deployment.

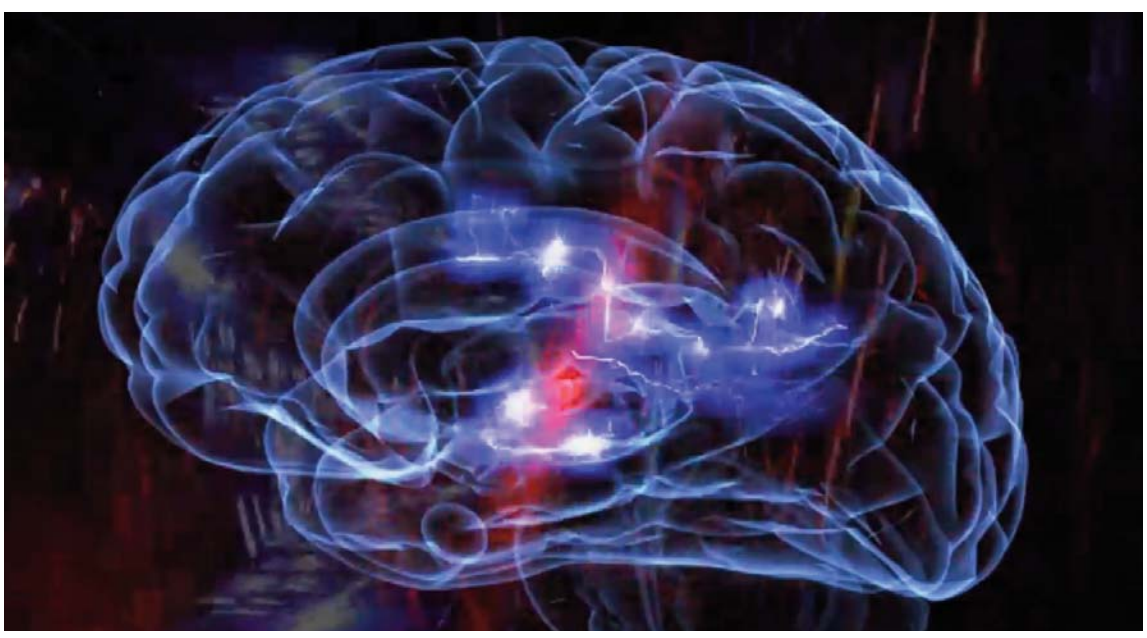
Full utilization of the Neuromorphic Cyber Microscope isn't going to be entirely smooth, warns Roger. "We as security analysts are going to have to rethink how we do things to make better use of this sort of a capability, he says. "We need to figure out how we describe the things that we're interested in and how do we apply them in the most efficient way possible."

Sandia and Lewis Rhodes Labs are exploring what else they can do with the general neuromorphic architecture. They've explored a type of machine learning used for audio and image processing and sorting numbers efficiently. John says they're still in early stages, looking at fundamental algorithms. This basic research is supported by Sandia's Laboratory Directed Research and Development program. John says, "Eventually, we'd like to have completely new algorithms that really take advantage of the way the brain actually does its operations."

David Follett has worked with Sandia off and on for more than 20 years. In fact, his earlier company jointly won an R&D100 award in 1996 for the ATM OC-12c Protocol Engine, a fast interconnect for computer-network communications.

"Sandia has a very unique culture and extraordinarily talented people," he says. "The technical breadth of the lab and domains where they have world-class-expertise is very impressive. It's an ideal environment for incubating novel, disruptive technologies like the Neuromorphic Cyber Microscope."

A video about the Neuromorphic Cyber Microscope is available at http://tinyurl.com/z32yegp.



Shoe Box Challenge shows creativity, ingenuity of engineers

By Sue Major Holmes
Photos by Randy Montoya

You could say water sank the bridges of Sandia.

The Labs' first Shoe Box Challenge handed out (what else?) plastic shoe boxes full of supplies to registered teams on Monday of Engineers Week in February. Teams could use only what was in the box to build a bridge — an engineering challenge kept secret until teams picked up their kit of 400 popsicle sticks, rubber bands, kite string, capacitors and resistors, 9-volt battery, and the like.

Working on their own time, teams had until judgment day on Thursday of Engineers Week to build their creation and decide whether to compete in the technical or creative category. All bridges had to go from spanning a 36-inch wide "river" painted on a test stand to moving to allow an 18-inch cube "ship" to slide by. Technical bridges then converted back to spanning the river and were weighed down until they failed. Creative bridges had to support at least 8 ounces in the center while spanning the river.

Popular vote determined the creative winner, and 24 teams posted videos for Sandians to choose their favorites. One video copied a newscast format. Another rolled credits with the notice, "No Sandians were harmed in the construction or filming of this bridge." The winning entry's announcer intoned, "The carnage of American bridge-making stops right here."

Judges tested 20 technical entries on the spot Thursday, three at a time on separate stands, timing how long each bridge took to get out of the way of the ship, then adding weight in the form of small water bottles until the bridge snapped or sagged into the river.

Teams added weight by suspending the bottles from plastic bags beneath the bridge. Watching one team stuff bag after bag, a bystander remarked, "If I were the Department of Transportation, I'd hire you guys." When two exceptionally strong bridges tested at the same time used up all 240 bottles of water, judges scrounged up metal to add weight. When teams packed so many bottles into bags that the bags failed before the bridges, judges found stronger bags.

One bridge was pronounced "a graceful failure" as it slowly sagged. Another buckled sideways instead of cracking.

Teams tweaked bridges even as they set up for judging. "Every time we do it, it changes because the rubber bands keep stretching," one team member complained while readying a bridge to raise. "No one brought a Phillips?" a member of another team asked as a colleague laboriously hooked the bridge to the stand with the wrong screwdriver. One team disqualified itself after realizing its elegant solution — a long row of popsicle sticks taped together with weight borne on strings and copper wire — didn't meet a requirement for distance to the water.

Being engineers, many teams conducted post mortems to figure out why their bridges collapsed. One group pointed out the glue failed, not the structure. When another post-failure review hit upon the probable weakness, a team member responded, "At midnight, that didn't seem so important."

"Midnight?" asked a bystander. "Really?"

"We're like college kids," the team member replied. "Wrinkly, old college kids."

TECHNICAL WINNER:
Watchmen,
supporting 91.93 pounds

CREATIVE WINNER:
Arcs and Sporks

STATS:
Some 461 people registered, but only about half ended up competing — 104 in the technical category and 118 in the creative category.

VIDEOS:
Creative category videos can be seen at e-week.sandia.gov

A head for business

Researchers who leave Sandia to start a company can now be joined by non-R&D staff

By Nancy Salem

Over the years, Genaro Montoya was asked every now and then why the entrepreneurial separation program he runs allowed only technical staff to leave the Labs to go into business. James Brimhall and Austin Trent wondered, too, and took the next step.

A grassroots effort by James (10248) and Austin (10656) has led to Sandia's Entrepreneurial Separation to Transfer Technology (ESTT) program being expanded to include staff in business or non-research and development (R&D) positions such as project management, accounting, and procurement. "I've always thought it was a good idea, that business people can help transfer technology to the private sector," Genaro (1933) says. "James and Austin were the first to take aggressive action to make the change."

For more than two decades, ESTT has let researchers take technology out of the Labs by leaving to start or join small companies with their Sandia jobs guaranteed for up to two years. The program has brought Sandia expertise into the private sector, created jobs, and contributed to economic development.

Genaro says the policy was limited to R&D staff because the intent is to transfer Sandia-developed technology. "Business people generally don't have enough knowledge around the technology to take it out and help commercialize it," he says.

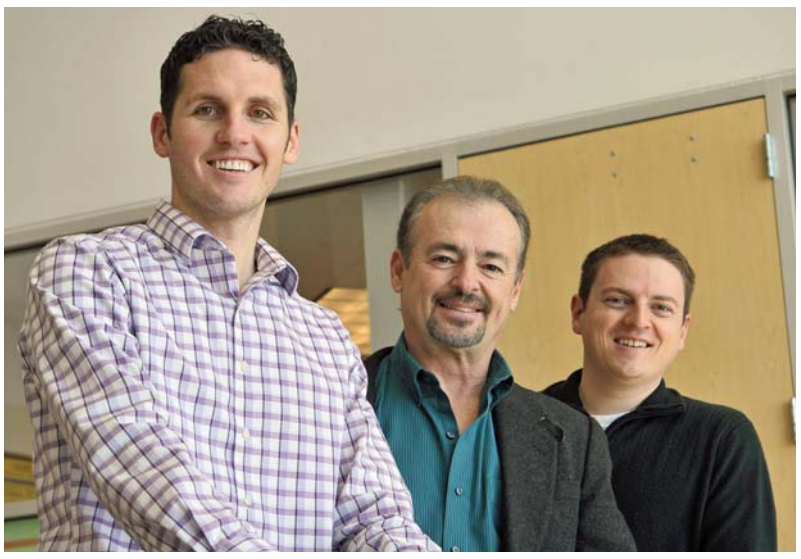
But he points out that many small technology-based companies fail because the founders lack business acumen around acquiring venture capital funding, legal requirements, and how to build a business structure. "There is a lot of expertise that business people bring to the table, so pairing them with inventors is smart," he says. "Successful startups in the private sector have a team with a strong business element, not just a technical person. Now that element can be found within Sandia."

Good business ideas

The new policy allows non R&D staff to partner with researchers who obtain a license from Sandia to patents or copyrights to start their own company. "A business person could not go start an accounting firm," Genaro says. "The policy is specifically intended to transfer Sandia technology into the private sector."

James says he began thinking about ESTT about a year ago as he met Sandia business colleagues who wanted to be entrepreneurs. "They have good business ideas," he says. "In a startup, you need business background behind the technology. I felt strongly that business people should be part of ESTT and have more opportunities to meet and brainstorm with scientists and engineers."

The idea resonated with Austin, whose father was a successful technology entrepreneur. "Eighty percent of startups fail in the first 18 months," he says. "I work with tech people whose projects have application in industry. We can help. I talked to a lot of different people who said it was a good idea to open ESTT to the business community, but they didn't think to try to change the policy."



GRASSROOTS CHANGE — Left to right, James Brimhall, Genaro Montoya, and Austin Trent worked together to change Sandia's Entrepreneurial Separation to Transfer Technology program to include non-R&D staff. James and Austin, who work in business operations, developed the proposal, got it approved in Div. 10000, and took it to Genaro, who carried it across the finish line.

James joined forces with Austin to submit the idea last fall to the SPARCK (Sharing Perspectives and Rethinking Common Knowledge) initiative run by iSOLVE, a Div. 10000 program to promote esprit de corps in the Sandia business community. It won the support of Div. 10000 management up through VP Jennifer Plummer. "It takes many skills to make a business work," Jennifer says. "Sandia's workforce is richly talented in countless areas of science, engineering, and business. By opening ESTT to non R&D staff, technical and business professionals can form productive partnerships. It's a common-sense expansion of the policy."

James and Austin took it to Genaro. "It was a solid proposal, and the environment around entrepreneurial activity is at a peak," says Genaro, who shepherded the change through Sandia's upper management. "The timing was good."

Bring people together

Genaro says he and others are looking into ways to bring business and technical people together to network and explore partnerships. One option is through Sandia's Entrepreneur Exploration (EEx) events.

"By extending ESTT to business as well as technical staff, a wider group of people can explore entrepreneurial opportunities related to Sandia technologies," says Andy McIlroy, director of Research Strategy and Partnerships Org. 1900. "Our business professionals can provide valuable complementary expertise to a team leaving on ESTT. And those who ultimately elect to return to Sandia bring new perspectives and methods that will enrich the Labs."

James and Austin are happy to have been the catalysts. "Anybody can be an innovator," James says. "We all have ideas and this policy change now gives us the ability to act on them. Having business and technical professionals work together will give startups a greater chance at success. We are a team here; we need to be a team out there."

Interested in entrepreneurship?

Scientists, engineers, and non R&D staff who want more information about the Entrepreneurial Separation to Transfer Technology program can contact Genaro Montoya at 505-284-0625, gmontoy@sandia.gov.

Sandia also offers an Entrepreneur Exploration (EEx) program designed to invigorate an entrepreneurial culture at the Labs and inspire researchers whether they leave or remain at Sandia. "We are encouraging people to think and act like both entrepreneurs and intra-preneurs," says Jackie Kerby Moore, manager of Technology and Economic Development Dept. 1933.

The program has been in place nearly two years and includes entrepreneur office hours, when researchers can meet and talk to members of the business community; workshops; roundtables; boot camps; and social gatherings.

EEx offers one event a month. Speakers have included Gary Oppedahl, the city of Albuquerque's economic development director and a serial entrepreneur; Lawrence Chavez, CEO of Lotus Leaf Coatings; and Chris Yeh of Wasabi Ventures.

"More than 900 community leaders, entrepreneurs, and Sandians have attended the EEx events," Jackie says. "It links the community to Sandia with opportunities for entrepreneurs."

Science Café – Nuclear energy risk perception

MATTHEW DENMAN grew up in a military family and lived in cities around the world, from Langley, Virginia, to Ramstein, Germany, and Okinawa, Japan. He earned a bachelor's degree from the University of Florida in 2007 and a doctorate from MIT in 2011, both in nuclear engineering. He joined Sandia two years ago in the Risk and Reliability group, where he led a multilaboratory review of safety and licensing gaps for the Sodium Fast Reactor and helped rewrite a Nuclear Regulatory Commission document on low-level radioactive waste disposal. Matt is now doing research into risk assessment methodologies.
(Photo by Randy Montoya)

By Stephanie Holinka

Sandia nuclear engineer Matt Denman (6231) had an interesting journey just prior to coming to Sandia, which he shared with attendees during the opening of the February edition of NMPBS' *Science Café*, held at the National Museum of Nuclear Science and History.

In early 2011, after defending his PhD thesis in nuclear engineering at the Massachusetts Institute of Technology, Matt attended a risk analysis conference in North Carolina. During that conference, Japan was struck by the 9.1-magnitude Great East Japan Earthquake and the subsequent tsunami that resulted in the Fukushima Daiichi nuclear power accident.

"I was trapped with a bunch of risk analysts in North Carolina during the accident. These engineers had spent their entire lives studying how nuclear power plants could melt down, which is either the best place to be or the worst place to be," Matt says.

Matt had defended his PhD thesis a few weeks earlier incorporating risk insights into the design of a sodium-cooled fast reactor. He had limited his analysis scope to include only internally induced accidents while acknowledging that the true limiting risks of these reactors would come from external events such as floods and earthquakes. While this limitation in research scope was acceptable to his thesis committee in February, had he waited to defend until after the Fukushima reactor accident in March, he likely would have been forced to expand the scope of his thesis to include external events, which could have added another year of research time to his thesis.

You'd think that beginning one's professional life concurrent with the largest nuclear accident might make a risk analyst less bullish on nuclear power. But you'd be wrong.

Matt says one of the reasons he became a nuclear engineer is because energy is a key component to ensuring a good quality of life for Americans and for the rest of the world. For business, and to extend the work week, the world needs lots of electricity. And overall, nuclear power provides the cheapest electricity safely, he says.

"Based on the data, nuclear power is far safer than other types of power generation. But people don't think of it that way, because they focus on the accidents at Chernobyl and Fukushima rather than the millions of people who die from pollution from other energy sources," Matt says.

People don't think about the risks associated with everyday activities, such as driving a car. They focus on the risks associated with things they don't have any control over, no matter how unlikely those events are, Matt says.

"Humans evaluate things in terms of dread. We will engage in extremely risky activity if we think we have some control over it. We discount the everyday risk, and we overestimate the risk of something like a nuclear accident, over which we have very little control," Matt says.

Matt says the nuclear industry does very expensive testing to characterize the risk of nuclear power plants, which other industries do not do. But even characterizing that risk accurately does not seem to help overcome the dread associated with nuclear power, no matter how safe it's proven to be.

"Part of my research is to study how different types of nuclear power plants can fail, and how different forms of electricity can kill you. I spend a lot of my time calculating 'deaths per year.' It's a little warped, but incredibly important."

After all his research of all the different types of electricity generation available, Matt says he has concluded that nuclear energy is among the safest.

"Fukushima did not change my view of nuclear power. Nuclear power is the cleanest option I have seen so far. But all human activities have pros and cons; there is no free lunch, but nuclear power is a cheaper lunch."

Matt is currently studying the risks of fire associated with sodium-cooled fast reactors.

The March *Science Café* will feature Leigh Ann Steele (2546) discussing battery research. Leigh Ann was one of two Sandia researchers who appeared in *NOVA's* recent episode "Super Battery."

Employee death

A pillar of his team and a merry prankster, to boot

There seemed to be nothing Sam Lucero couldn't do, and do well, friends recall

With a distinguished career that spanned a diverse collection of departments from pulsed power to power sources to materials science and corrosion, Sam Lucero (1852) touched the lives of many at Sandia. Sam passed away in January at age 56.

As friend and colleague Jeff Braithwaite (retired) says, "Sam's effectiveness was simply unmatched, and appropriately, he was promoted to Sandia's Distinguished level even before he was officially eligible." That sentiment was echoed by almost everyone who knew and worked with Sam.

SAM LUCERO

Sam was everyone's go-to guy for solving all types of practical problems — and that included everything from how to do electrical or plumbing work around your home, to diagnosing and fixing vehicles to just about everything. The near-constant stream of folks from around the Labs coming to his office for help was a testament to that. As Doug Wall (0153) puts it, "He was the ultimate sounding board for ideas, an intuitive problem-solver who was so quick on his feet that sparring with him verbally was almost always a losing proposition."

At his memorial service, as part of a touching recollection of his uncle, Sam's nephew recalled how Sam stood in as an in-house science teacher, helping him and his mother fix an experiment and showing him how it's done.

As Sam's former manager Jill Glass (2547) puts it, "He was a pillar of the department, keeping our operations safe, training and mentoring others including me, finding ways to make a difference every day, and regularly accomplishing the most challenging of tasks."

Friend and colleague David Enos (1852) notes that, "Sam was one of those folks who made it fun to come to work, and it's been an honor to have him as a friend," a sentiment echoed by many others.

While his accomplishments at work were truly exceptional, that's not what really set Sam apart. David explains, "Never before have I had the pleasure of knowing someone so kind-hearted and full of life. He was always there for anyone and everyone who needed him."

Rob Sorensen (1852), another long-time colleague and friend, says, "He had a huge heart and would do anything for anybody." Jeff Braithwaite added that he would remember Sam for his "constant interest in others, his compassion and understanding, his patience, his energy, and his always up-beat and positive attitude."

Sam was able to understand what folks needed, and how their circumstances often played a role. As Don Bradley (1833) notes, "He taught me as we worked together at Sandia Labs. His wry sense of humor and his keen insights into the environments we shared helped me to understand." Sam's capacity and desire to help others continued to the end. Long-time friend and colleague Patti Sawyer (1853) recalls that "the pain he endured the last year or so made me realize what an incredible spirit Sam had — he still helped everyone, no matter how he felt."

Loved challenges that tested his knowledge

Outside of work, Sam had a vibrant life. He enjoyed bow hunting, fishing, camping with his family, and wrenching on his vehicles. He enjoyed taking on challenges that tested his knowledge. He was a generous man with his time and knowledge and did not hesitate to help anyone in need. He never stopped learning and always found a solution to any problem.

Sam also had a mischievous side, as Rob Sorensen knows first-hand. "He had a great sense of humor and loved to pull pranks on people. Most of us have been on the receiving end at some point. It was never malicious, and we could all laugh with him."

Jill adds that while she knew Sam, "My legs were frequently being lengthened in the years before I caught on that he could keep a completely straight face while telling me one kind of fish story or another." Coby Davis (1852), Sam's manager, recalls that "I will remember him for his compassion, his humility, and mostly for his wry smile and the twinkle in the eyes that let me know that I was about to have my leg pulled."

And Kylen Johns (0435) adds, "I'm truly thankful for these laughs, and for knowing Sam. His genuine and kind spirit was a joy to be around."

Sam is survived by his mother, Victoria; his beloved wife of 10 years, Sandra; son, Samuel III (Sarah); stepdaughter, Crystal (Joel); stepson, Justin; grandchildren Elijah, Alena, Mariah, Isaiah, Ariana, Alexa, Kylie, and Nolan; one brother, Frank (Joann); three sisters: Carlotta (Louis), Carmen, Alberta (Michael); three nephews; four nieces; and a host of friends and loved ones. He was preceded in death by his father, Samuel Lucero Sr. — *David Enos*

Academic Alliance workshop focuses on autonomy R&D

SANDIA RESEARCHER BILL HART, right, moderates a panel discussion during the inaugural Academic Alliance workshop on Autonomy and Complex Systems. Alliance university participants, from left, included researchers from the University of Illinois at Urbana-Champaign, University of Texas, Austin, University of New Mexico, Purdue, and Georgia Tech. (Photo by Randy Montoya)

Representatives from Sandia and the Labs' Academic Alliance university partners convened March 3 for the inaugural Academic Alliance workshop on Autonomy and Complex Systems. The workshop focused on how academic partnerships can leverage the intersection of complexity and autonomy R&D for success.

The workshop was designed to align with Sandia's Resiliency in Complex Systems Research Challenge, one of the Labs' 11 active research challenges, which are intended to produce breakthroughs that impact the mission and contribute in their own right to advancing the frontiers of science and engineering.

Participating Alliance schools included Georgia Institute of Technology, Purdue University, University of Illinois at Urbana-Champaign, University of New Mexico, and the University of Texas at Austin.

Recent advances in artificial intelligence, spurred on by the availability of new hardware that is enabling deeper and cheaper machine learning, has raised interest in autonomous systems among academia, government, and industry.

Workshop organizers say these new technologies present both opportunities and challenges for national security. Solving the toughest of these national science and technology problems, they add, will require partnerships between national laboratories and universities.

The Academic Alliance initiative links faculty, students, and researchers at key universities with Sandia scientists and engineers to develop collaborative solutions to mission-critical challenges.

Workshop participants explored the use of complex systems approaches across autonomy-related topics such as human-machine teaming, artificial intelligence and machine learning, and distributed autonomy and cooperative systems. Participants discussed how the application of complex systems science can help researchers better understand the opportunities and risks in these research areas, and identified technical gaps that complex systems research can address.

In a wrap-up at the end of the workshop, participants found areas of common interests, but with universities and Sandia researchers focusing attention on different aspects of autonomy research. Specifically, university researchers were drawn to push the technical limits of the possible and "cool" for autonomous systems, while the Sandia researchers, with an eye on mission requirements, expressed concern about issues of resilience, reliability, transparency, security, and trust in the adoption of these systems for national security applications.

A long term, sustained initiative in autonomy for national security, participants agreed, will require a new paradigm and capabilities for testing and evaluation during design that can provide assurance of autonomous systems under myriad conditions.

Mileposts

New Mexico photos by Michelle Fleming

California photos by Randy Wong

Sam Holmes
40 4238

Bill Silva
35 2556

Tommy Goolsby
30 6835

Gene Kallenbach
30 6831

Sandy Sanzero
30 6825

Bob Graham
20 5784

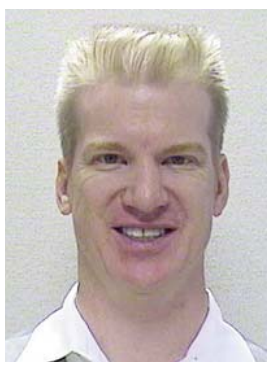
Mark Lynam
20 9514

Rebecca Ullrich
20 9532

Gary Whitlow
20 5771

Denise Black
15 10654

Eric Capener
15 2662



John Clem
15 6612

Chuckie Crawley
15 4848

Phap Dinh
15 2616

Isaac Garcia
15 5345

Stephen Graham
15 2956

Dee Dee Griffin
15 9011

Marianne Hill
15 11000

Theresa Keener
15 10660

Erica Lopez-Hamby
15 10650

Mike McLean
15 2242

Lin Nguyen
15 2663

Cheryl Post
15 5551

Steve Rinaldi
15 5643

Jim Stephens
15 10661

Mike Vining
15 2723

Frank Young
15 5539

Recent Retirees

New Mexico photos by Michelle Fleming

California photos by Randy Wong

Gwen Drake
38 810

M. Christine Garcia
36 5097

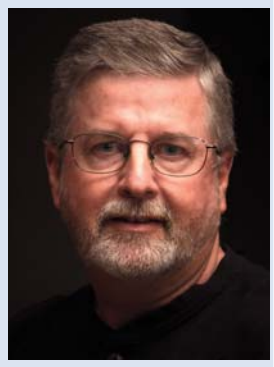
John Baney
34 2999

Dean Dobranich
34 1514

George S. Greer
34 5965

Arnel Oczon
30 2668

Bill Tedeschi
31 5900



Keith Bauer
28 5561

Len Malczynski
28 159

Anne Moats
27 5523

Retiring and not seen in the Lab News pictures:

David Duggan (9526), 33 years.

SANDIA CLASSIFIED ADS

MISCELLANEOUS

GYM EQUIPMENT, Bowflex Ultimate w/leg bench, $500; Horizon Elite 1.1T treadmill, $300; Proform Spincycle, $225. Bruskas, 323-1055.

'DIRTY DANCING' TICKETS, 2, June 16, 8 p.m., Popejoy, balcony, front row center, $100. Pucket, 298-6067.

CAT TREE, Pawhut, 57-in., put together, brand new, it's the wrong size, cost $85.99, asking $65. Carian, 505-440-2141.

CAMERAS, Canon EOS 50D, body/lens, $400; EOS Rebel, body/lens, $225; plus accessories, $100. Greene, 802-578-2056.

DESK BASE & HUTCH, cherry finish, 30"W x 76"T, keyboard drawer, like new, $100. Anderson, 263-5057.

WHEELS, '16 4Runner, new trail edition, 17-in., $400. Raether, 505-363-1631.

WOODWORKING & METAL WORKING TOOLS, both portable & hand-held, many available, low price, must sell. Bear, 881-7128.

ELTON JOHN TICKET, March 22, Tingley, section E, row 7, seat 7, paid $172.25, asking $100. Shaw, 505-980-7491.

GOOSENECK TRAILER, 16-in., dovetail, 6'W x 16'L, 7,000-lb. load, $4,000. Larsen, 263-5053.

COMPOUND BOW, PSE Phenom, RH, blue, #40-#60, 27-33-in. draw, adjustable sight, drop away rest, $400 OBO. Schroeder, 505-917-4516.

METAL WORKING LATHE, 7" x 10", floor stand, 2 & 4 jaw chucks, drill chuck, hardly used, $499. Woods, 720-8492.

TRUNDLE BED, twins-to-queen, steel frame, pillow-top mattress, new linens, very little use, like new, $150. Hollister, 717-2276.

'AN AMERICAN IN PARIS' TICKETS, 2, Popejoy, Sunday, Oct. 22, 1 p.m., orchestra seats, G309 & G310, $127/pair. Wood, 505-228-0193.

BURIAL PLOTS, 2, adjacent, Fairview Memorial Park, 700 Yale SE, $2,500 OBO. Lunsford, 286-4850.

SLIDE PROJECTOR, Airequipt, w/magazines, both rectangular & circular, also movie projector, $100. Genelia, 836-6977.

STROLLER, BOB Revolution CE dually, best stroller ever, w/handlebar console ($28), excellent condition, $415. Colborg, 604-4915.

TONNEAU COVER, '16 OEM hard tri-fold, w/options, Tacoma double cab, short bed, $700 OBO. Shaw, 505-377-4914.

BOWFLEX M5 MAX TRAINER, minimally used, $1,600 new, asking $1,000 OBO. Eckstein, 505-681-0736.

WOODWORKING EQUIPMENT, Craftsman, table saw, drill press, band saw, planer, De Walt planer, $200 ea. OBO. Tenorio. 505-217-6422.

GAS STOVE, white, GE, $150 OBO; dark cherry wood entertainment center/armoire, $200 OBO. Brito, 822-1201.

FREE TALK, Ann Beyke speaking on "Grieving the Loss of a Pet," details at http://fabulousFelines.org. Stubblefield, 263-3468.

FIESTA WARE GLASSES, 16-oz. Elegance goblets, clear w/cobalt bands at base, 10/$40. Hall, 280-4344.

DINING ROOM TABLE, New! Oak, Dbl. Pedestal, 4 ft. wide, 8 ft. long, incl. (2) 16" leaves. $500; will consider offer. Amend, 453-4751.

TRANSPORTATION

'86 FORD F250, 6-cyl., 4-spd., functional lift gate, Ethridge Tire Center tune-up available (883-7206), 176 miles, under hood new, $5,000. Brunacini, 505-883-2557.

'98 VOLVO S70 TURBO, brand new tires, 60K warranty, clean, 150K miles, $3,500. Barraza, 505-595-4030.

'09 JEEP GRAND CHEROKEE LAREDO, AT, 37K miles; '11 Toyota Tacoma, 4x4, AT, 90K miles. Fenimore, 228-0556.

'07 MERCEDES ML350, fully loaded, all service records, 96K miles, great condition, $12,999. Jones, 413-687-7013.

'99 FORD TAURUS, small AC & oil leak, 161K miles, good condition, $1,000. Hautzenroeder, 505-715-3745.

'11 BMW 135i, black exterior/interior, clean, 51K miles, $19,500 OBO. Wareing, 505-652-2883.

'05 HONDA CRV, AWD, great mechanically, 200K highway miles, good tires, needs no work, $2,700. Kennicott, 505-259-0826.

RECREATION

'03 FLEETWOOD TIOGA RV, sleeps 6, 26K miles, excellent condition, $16,500 OBO. Ortiz, 505-350-4845.

'08 HONDA 600RR SPORT BIKE, minor cosmetic damage, orange/black, geared for SMRI track, 2,700 miles, $4,300. Delgado, 505-917-7090.

'07 FLEETWOOD POP-UP CAMPER, AC, shower/bathroom, refrigerator/stove, awning, dining room slide out, excellent condition, $5,500. Garner, 505-269-9151.

REAL ESTATE

3-BDR. HOME, 2 baths, 1800+-sq. ft., 2-car garage, w/custom cabinets, Four Hills, solar panel, open concept, fully remodeled, $275,000. Newell, 331-0187, ask for Pania or Robert.

2.67 ACRES, Landess Lane, Jarales NM, Valencia Co., gas, electric, internet, TV, 34.598964,-106.765915 in Google Maps, $28,000. Gurrieri, 505-856-1688.

3-BDR. HOME, 2 baths, laundry room, Nob Hill area, updated kitchen/master, mountain views, MLS#884765, $324,000. Abetya, 505-573-8195.

5-BDR HOME, 3 baths, 4,280-sq. ft., separate in-law quarters, swimming pool, https://tinyurl.com/m7alqkc. Ramos, 972-951-0290.

4-BDR. HOME, for rent, 2-1/2 baths, 3,060-sq. ft., available mid-April, stainless, granite, upgrades, $2,300/mo., going on assignment for Sandia. Pepple, 331-1381.

3-BDR. HOME, for rent, 3 baths, 2,050-sq. ft., fully furnished, High Desert community, going on assignment for Sandia. Hymel, 505-228-1723.

WANTED

SHORT-TERM HOUSE OR CONDO RENTAL, for visiting family, NE Heights preferred, 2-4 wks., mid-June to mid-July. Greathouse, 821-0980.

RESPONSIBLE HOUSE SITTER, Mon-Thurs. nights, Edgewood, March & April, must love dogs & llamas, have references. McNamara, 505-720-4946.

MOVING BOXES, all sizes, will pick up. Martinez, 505-903-0911.

How to submit classified ads

DEADLINE: Friday noon before week of publication unless changed by holiday. Submit by one of these methods:

- **EMAIL: Michelle Fleming (classads@sandia.gov)**
- **FAX: 844-0645**
- **MAIL: MS 1468 (Dept. 3651)**
- **INTERNAL WEB: On internal web homepage, 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.

Ad rules

1. Limit 18 words, including last name and home phone (If you include a web or e-mail address, it will count as two or three words, depending on length of the address.)
2. Include organization and full name with the ad submission.
3. Submit ad in writing. No phone-ins.
4. Type or print ad legibly; use accepted abbreviations.
5. One ad per issue.
6. We will not run the same ad more than twice.
7. No "for rent" ads except for employees on temporary assignment.
8. No commercial ads.
9. For active Sandia members of the workforce, retired Sandians, and DOE employees.
10. Housing listed for sale is available without regard to race, creed, color, or national origin.
11. Work Wanted ads limited to student-aged children of employees.
12. We reserve the right not to publish any ad that may be considered offensive or in bad taste.

FEMALE ROOMMATE, 2 bdr. apt., 15 mins. from Sandia, $420/mo. Reif, 505-681-9350, text or call.

Recent Patents

Note: Patents listed here include the names of active and retired Sandians only; former Sandians and non-Sandia inventors are not included. Following the listing for each patent is a patent number, which is searchable at the US Patent and Trademark Office website (www.uspto.gov).

* * *

Anna Tauke-Pedretti (1764): Transparent Contacts for Stacked Compound Photovoltaic Cells. Patent No. 9,508,881.

C. Jeffrey Brinker (1000): Protocells and Their Use for Targeted Delivery of Multicomponent Cargos to Cancer Cells. Patent No. 9,480,653.

Susan Rempe (8635) and Jeffrey Brinker (1000): Biomimetic Membranes and Methods of Making Biomimetic Membranes. Patent No. 9,486,742.

Khalid Mikhiel Hattar (1111), and Stuart B. Van Deusen (1111): Single Crystal Micromechanical Resonator and Fabrication Methods Thereof. Patent. No. 9,525,398.

Chris Jenkins (5627): Apparatus, Method and System to Control Accessibility of Platform Resources Based On An Integrity Level. Patent No. 9,479,513.

Timothy N. Lambert (6124): Conductive Polymer Layers to Limit Transfer of Fuel Reactants to Catalysts of Fuel Cells to Reduce Reactant Crossover. Patent No. 9,515,340.

Paul J. Resnick (1719), Anthony L. Lentine (1765), and Vipin P. Gupta (6124): Customized Color Patterning of Photovoltaic Cells. Patent No. 9,496,448.

Brett Bagwell (5331): Direct View Zoom Scope with Single Focal Plane and Adaptable Reticle. Patent No. 9,494,787.

Lisa C. Marron (5954), Stephen Buerger (6533), and Michael A. Martinez (6533): Electromechanical Latch. Patent No. 9,518,406.

Erik J. Skogen (1764): Guided-Wave Photodiode Using Through-Absorber Quantum-Well-Intermixing and Methods Thereof, Patent No. 9,477,040.

David Adams (1832), Aaron C. Hall (1832): High Durability Solar Absorptive Coating and Methods for Making Same. Patent No. 9,499,699.

William A. Zortman (5627): High-Speed Optical Phase-Shifting Apparatus. Patent No. 9,488,854.

Scott E. Bisson (8128) and Daniel Beom Soo Soh (8128): High-Yield Entangled Single Photon Source. Patent No. 9,465,274.

Timothy Boyle (1815): Hydrothermal Synthesis of Bismuth Germanium Oxid. Patent No. 9,518,219.

David Bruce Burckel (1765), Patrick Sean Finnegan (1853), David R. Wheeler (5964), Cody M. Washburn (5965) and Timothy N. Lambert (6124): Lithographically Defined Microporous Carbon-Composite Structures. Patent No. 9,513,554.

Michael E. Chandross (1814), Timothy J. Boyle (1815), Ping Lu (1819) and Paul T. Vianco (1831): Low-Temperature Nanosolders. Patent No. 9,463,532.

STEM Day opens the Labs to young learners

By Valerie Larkin • Photos by Randy Montoya

On Tuesday, Feb. 28, Sandia welcomed 100 New Mexico students for a day of interactive science, technology, engineering, and math (STEM) activities.

STEM Day at the Lab introduced middle and high school students, traditionally underrepresented in STEM fields, to careers and role models through hands-on sessions that combined instruction and mentorship.

Groups of students rotated through eight exploration stations, learning from researchers at each stop. The stations showcased a wide range of Sandia's research and development work from chemistry to cognitive science and eye tracking, as well as nondestructive testing, an infrared camera, environmental models, a sticky foam demonstration, and more.

Sandia researchers educated the students about the scientific concepts on display and discussed their own STEM career paths. More than 35 Sandia employees, including members of Sandia's Black Leadership Committee, the Hispanic Outreach for Leadership and Awareness group, and the American Indian Outreach Committee, helped with the event.

Staff from Sandia/California participated by volunteering at Lawrence Livermore National Laboratory's STEM Day on March 2. Sandia employees led students on a tour of the National Ignition Facility, sat with them as lunchtime mentors, and presented three hands-on STEM activities.

"We're excited to open our doors to these students from our community. We want them to see the wide range of opportunities available to them when they study and work in STEM, and to benefit from the expertise we have right here in our community," says Katrina Wagner (3652), the community relations specialist who organized the New Mexico event.