High-speed experiments improve hypersonic flight predictions

Hydronomic computing demonstrates high efficiency, performance

Forbes names Sandia a top large employer for 2019
This is the first in a series of columns exploring Sandia’s seven Strategic Priorities — areas where Labs leadership believes it is important to dedicate institutional time, attention and resources to significantly impact national security. The priorities look ahead 20 years and are part of Sandia’s Creating the Future strategic direction document.

Read about Labs strategic planning in the Jan. 31 Lab News.
California middle school students get look at STEM careers

By Michael Padilla
Photos By Dina Vournas

From designing a paper airplane to learning all about research in an ultrafast laser lab, more than 35 students recently took part in Career Exploration Day with Citizen Schools at Sandia/California.

The nonprofit Citizen Schools partners with middle schools across the nation to extend learning for youth in underserved communities.

The goal of the event was to expose students to careers in science, technology, engineering and math. Students took part in hands-on science demonstrations and toured two labs in Sandia’s Combustion Research Facility. During the event, students questioned researchers about STEM careers.

“Sandia is committed to delivering STEM educational outreach opportunities designed to increase the number of underrepresented students who successfully pursue STEM careers,” said Doris Ellis, associate labs director for Integrated Security Solutions. “Career Exploration Day with Citizen Schools was an excellent opportunity to give students firsthand exposure to a national laboratory and provide students with career-building skills and takeaways to use in their future academic paths and careers. Perhaps as important, the individuals who engaged with the students represent a diverse group of men and women that are role models for what these students can aspire to be.”

Systems engineer Camron Proctor welcomed the students to Sandia and spoke about his work at the Labs. “I see a lot of myself in these kids, and their background resonates with me,” Camron said. “I wanted to highlight the similarities so that they could see what I didn’t at their age. It is important to me that they see someone who is, like them, deeply engaged in science and engineering.”

Systems engineer Raheel Mahmood and Adriana Del Cid, community relations intern, welcomed the students and led the paper airplane design demonstration.

During the event, Dori presented a check for $15,000 to Maria Drake, executive director of Citizen Schools, to support ongoing science programs. “It was super exciting to hear students express their intentions of sharing their experiences with siblings and friends,” Adriana said. “I heard a specific student looking forward to showing her younger brother how to make a paper airplane using the airplane demo sheet. Hearing this highlights the importance of having these outreach events and field trips for students because they not only impact the students attending, but also have the power to reach others in the students’ lives, sparking their curiosity in STEM.”

Sandia supports Citizen Schools as part of the Labs’ commitment to educational success. This effort includes recruiting current members of the workforce to volunteer to teach 10-week apprenticeships at underserved middle schools. A team of Sandia volunteers also put together the career exploration event.

The event was spearheaded by Kayla Norris, community relations specialist, and Adriana. Volunteers included Neil Cole-Filipiak, Mark Musculus, Chris Kliewer, Holly Gothard and Patrick Joseph Blonigan. Zoe Pilla served as the Citizen Schools coordinator.

Bridging the gap between scientists and politicians

By Valerie Alba

Vic Reis, former DOE assistant secretary for Defense Programs, offered a history of U.S. science funding in his recent talk for Sandia’s National Security Speaker Series.


Before World War II, he said, scientific research was funded mostly by commercial interests or universities, and the move to government-funded research gave rise to distrust between politicians and scientists.

“You get a situation where Eisenhower is saying, from a policy perspective, don’t trust the scientists. From the scientific perspective, Feynman was saying don’t trust the politicians,” Reis said.

“I found myself in my career for the most part in the middle of that, at the juncture between science and policy, and the approach I’ve taken is to use systems analysis as a way of bridging that gap to maintain the trust between the political people and the science people,” he said.

The “four prunes” are a reference to John H. Trattner’s “The Prune Book: The 60 Toughest Science and Technology Jobs in Washington.”

Reis said he held four of those during his career: working in the Office of Science and Technology Policy; director of the Defense Advanced Research Projects Agency; DoD director for research and engineering; and, at DOE, as the original sponsor and architect of the Stockpile Stewardship Program.
Improving hypersonic flight predictions

Simply put, being able to characterize and predict these pressure spots leads to better vehicle design.

“The understanding of unsteady pressure fields is extremely important for modeling of hypersonic flight vehicle applications for a variety of national security programs,” said Basil Hassan, senior manager.

“This advanced diagnostic development work forms unique datasets for fundamental discovery and model validation at Sandia and has been used to improve flight predictions for several national hypersonic flight programs,” Basil said.

Over the past several years, Katya’s experiments have progressed from the use of miniature electronic sensors to advanced imaging techniques with pressure-sensitive paint, which is applied to a model tested in a wind tunnel and viewed by specialized cameras to measure the pressure fluctuations optically.

The American Institute of Aeronautics and Astronautics recently cited Katya’s breakthrough in characterizing hypersonic turbulent spots and her work with novel fluctuating pressure instruments when announcing earlier this year she had won the organization’s Lawrence Sperry Award, given to notable contributions in the field by a person age 35 or younger.

Katya’s experiments characterizing hypersonic turbulent spots used innovative diagnostic techniques to provide insight into the interaction between pressure fluctuations and vehicle structural response.

With advanced imaging techniques and high-speed sensors, the work showed that transitional pressure fluctuations are generated by intermittent turbulent spots that pass by in a millisecond. As the spots grow, they merge into a fully turbulent layer. The data Katya captured was instrumental in improving predictive computer simulations developed by her colleagues at Sandia.

Using a cone-shaped model with an integrated thin panel embedded with pressure sensors and accelerometers at Sandia’s hypersonic wind tunnel, Katya studied the response, or vibration, to turbulent spots.

When the frequency of the passing turbulent spots matched the natural structural frequency of the panel, strong resonance was generated with vibration levels more than 200 times larger than when the spots were mismatched to the panel, she said. “This would be a worst-case scenario for the flight.” Now engineers have an improved means of predicting such a scenario and adapting to it.

A lot of Katya’s work occurs at Sandia’s wind tunnels, but it doesn’t stop there. Last year, she migrated similar pressure diagnostics to Sandia’s blast tube to demonstrate in larger field tests the pressure-sensitive paint technique first used in the wind tunnels. Katya combined intricate lighting, high-speed cameras and the carefully formulated chemistry of pressure-sensitive paint to capture the effect of a shock wave rolling across a vehicle.

Like the turbulent spots in the wind tunnel, the shock wave creates unsteady pressure loading that can vibrate a flight vehicle.

With an explosive charge detonated at one end of the 6-foot diameter blast tube, a shock wave travels through the tube before hitting a model at the other end. Traditionally, hundreds of small pressure sensors would be placed on the model to measure the force. Instead, Katya proposed using pressure-sensitive paint.

“With sensors, you can only get pressure readings at the discrete locations of where they’re placed,” Katya said. “With the paint you can get data everywhere.”

In August, the paint was airbrushed on a model nose cone. Four high-powered, water-cooled ultra-violet lights were shone on the pressure-sensitive paint, causing it to fluoresce. The more oxygen the paint is exposed to, the less it fluoresces. The greater the pressure, the greater the oxygen. So as the shock wave from the blast passed over the model, increasing pressure on its surface, the intensity of the paint’s glow decreased.

Caught on a high-speed camera shooting at 25 kilohertz (or 25,000 cycles per second) with a filter used to block the ultraviolet lighting, the result is a dark shadow growing over the model from the tip to the base; and then as a reflected shock passes by, the shadow encroaches from base to tip.

The change in the paint’s fluorescence can be calibrated to the amount of pressure exerted on the model.

Katya and her team conducted eight blast tube runs over two days and learned a few valuable lessons from the first-of-the-kind tests. For example, the tests collected better data when it’s dark, or at least cloudy, as sunlight interferes with the paint’s fluorescence.

“It’s a new approach for measuring pressure taken to the blast tube,” she said. “Overall, the tests were successful, and with a few adjustments should ultimately be useful in determining how to protect objects from shock waves.”

National Day of Prayer

A large gathering from Sandia and Kirtland Air Force Base (top photo) celebrated the 2019 National Day of Prayer May 2. Lt. Col. Jeff Granger, Kirtland wing chaplain (bottom photo), led attendees at the Steve Schiff Auditorium in prayers, along with Cindy Fulcher, N.M. State Police Deputy Chief Jose “Nic” Aragon and David Eiffert, pastor of the Believers’ Center of Albuquerque. God’s House of Praise choir and the Sandia Singers provided music for the event. Other speakers included Jeff Martin and John Clymo, associate Labs director for Infrastructure Operations. The event theme this year was “Love one another, as I have loved you.” Sponsors were Sandia’s Christians in the Workplace Networking Group and the Kirtland Air Force Base Chaplain Corps. Information about the Sandia group is available at cwns.sandia.gov.
Experiments at Z Machine earn Gomez research honors

By Neal Singer

S andra physicist Matthew Gomez has been awarded the 2019 Institute of Electrical and Electronics Engineers’ Nuclear and Plasma Sciences Society Early Achievement Award.

Only one scientist in the world receives the award each year. The award recognizes excellence in technical contributions to the fields of nuclear and plasma science that take place during the first 10 years after the honoree completes their degree.

An experimental high-energy density physicist, Matt holds a doctorate in nuclear engineering and radiological sciences from the University of Michigan. Matt was honored for contributions to magnetically-driven high-energy-density physics, and for leadership in the experimental demonstration of a magneto-inertial fusion concept with the possibility of scaling to ignition.

He has led more than 90 experiments on the Z facility and published not only about plasma formation in the high-current power feed on Z, but also about the first experimental results of the Magnetized Liner Inertial Fusion concept. His publication on the first MagLIF experiments has received more than 130 citations in the last four years, and he has given 11 invited talks on MagLIF during roughly the same time span.

Other Sandians who have won the award in the last decade include Dave Ampleford and Brent Jones.

Neuromorphic computing

This work, published last month in Science, introduces a novel approach to parallel programming of an ionic floating-gate memory array, which allows processing of large amounts of information simultaneously in a single operation. The research is inspired by the human brain, where neurons and synapses are connected in a dense matrix and where information is processed and stored at the same location.

Sandia researchers used parallel computing to demonstrate how to adjust the strength of the synaptic connections in the array so that computers can learn and process information at the point it is sensed without transferring it to the cloud. This greatly improves speed and efficiency and reduces power use.

Through machine learning technology, mainstream digital applications can recognize and understand complex patterns in data. For example, virtual assistants such as Amazon’s Alexa or Apple’s Siri sort through large streams of data to understand voice commands and improve over time.

With the dramatic recent expansion of machine learning algorithms, applications now demand much more data storage and power to complete these difficult tasks. Traditional digital computing architecture isn’t designed or optimized for artificial neural networks that are essential to machine learning.

To further compound the problem, conventional semiconductor fabrication technology has reached its physical limits. Chips simply cannot be shrunk further to meet the demand for energy efficiency.

“With the ability to update all of the data in a task simultaneously in a single operation, our work offers unmistakable performance and power advantages,” said Sandia researcher Elliot Fuller.

“This is projected to improve machine learning while using a fraction of the power of a standard processor and 10 times higher speed than the best digital computers.”

The work demonstrates the fast speeds, high endurance and low voltage critical for low-energy computing, which are becoming more important in such applications as driverless cars, wearable devices and automated assistant technology. As society increasingly relies on these applications for health and safety functions, improved accuracy and speed without reliance on cloud computing becomes critical.

The technology introduces a novel redox transistor approach into conventional silicon processing. The redox transistor — a device that functions like a tiny rechargeable battery — relies upon polymers that use ions to store information, not just electrons as with conventional silicon-based computers.

Future Sandia research will focus on understanding the fundamental mechanisms that govern how redox transistor devices operate, with the goal of making them more reliable, faster and easier to combine with digital electronics. Researchers are also interested in demonstrating larger, more complex circuits based on the technology.
Army Lab geophysicist details shifting Arctic climate

A federal geophysicist told a Sandia audience last month that understanding rapidly changing Arctic weather conditions is vital to understanding the global climate.

“We can’t ignore Alaska. It’s not just their problem; it’s ours,” said Martin C. Jeffries.

Jeffries is acting technical director and research physical scientist at the U.S. Army Cold Regions Research and Engineering Laboratory. His talk was titled “Understanding and Predicting Rapidly Changing Arctic: The Need for Enhanced Collaboration in Research.”

Among problems he discussed was the dramatically named polar vortex, credited with bringing wildly cold temperatures to the Midwest.

“The polar vortex has gotten the attention of many people over recent years,” Jeffries said. “It happens because the jet stream is weakening and doing more meandering. That’s because the Arctic is warming more quickly, which breaks down temperature differences” between Alaska and the lower 48 states. “There have been outbreaks of (extreme cold) but now they are happening more frequently and in longer duration.”

Jeffries, former executive director of the Interagency Arctic Policy Committee and past member of the White House Office of Science and Technology Policy, delivered his low-key insights with a calm demeanor that lent additional emphasis to his analysis.

“No only has cold air reached south, but warm moist air gets up into Alaska, which leads to more rain in winter, creating thicker ice that changes the earth’s energy balance,” he said. “The ice has become much ‘younger,’ a proxy term for thinner.”

The ice, which breaks up more easily, leads to a dark ocean that absorbs energy and warms, rather than an iced-over ocean that reflects incoming energy upward. The thin ice also is weaker in restraining waves from crashing onto the coast where Native Alaskans live.

Jeffries left the changing face of nature to mention this year’s commercial shipping that has provided new collaborations among scientists: “A bright spot,” he said unexpectedly, “are lower-cost airfares.”

Increasing interest in the changing Arctic also has led to widely attended ministerial-level meetings to discuss Arctic-area problems and their larger implications. The sessions took place in 2016 and 2018 in the U.S. and Germany, respectively, with a third to be hosted by Iceland in Japan in 2020.

Jeffries’ talk, held in a small Sandia lecture hall, attracted an audience of about two dozen, with 50 to 60 watching online. The talk was sponsored by Sandia’s Earth Science Research Foundation Speaker Series.

The next scheduled speaker in the series is U.S. Arctic Research Commission chair Fran Ulmer on May 23 at the Steve Schiff Auditorium.
New Mexico photos by Michelle Fleming
California photos by Randy Wong

Mileposts

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New Mexico photos by Michelle Fleming
California photos by Randy Wong

Eubank Gate Security Improvement Project

Scheduled to start 2019

01. Try out a different route and gate
02. Catch a carpool, vanpool, or ride to work with a friend
03. Determine what alternative commute works for you

Retiring and not seen in the Lab News pictures: Jane Hillman, 16 years.
Training to defend

Sandia’s Security Police Officers go through intense weapons training annually to protect members of the workforce from any possible threat, and that training recently took place at Sandia. The officers follow up the multi-day training program by going through weapons qualification six months later. “It is critical that each officer has the skills and confidence to react instantly to any threat Sandians face,” said Captain Pablo Montoya, a 34-year veteran of the force. “Our training is rigorous and so is the qualification. That is strengthened with active shooter drills and classroom training.” This is the 69th year of operation for Sandia’s protective force.
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Photos By Randy Montoya