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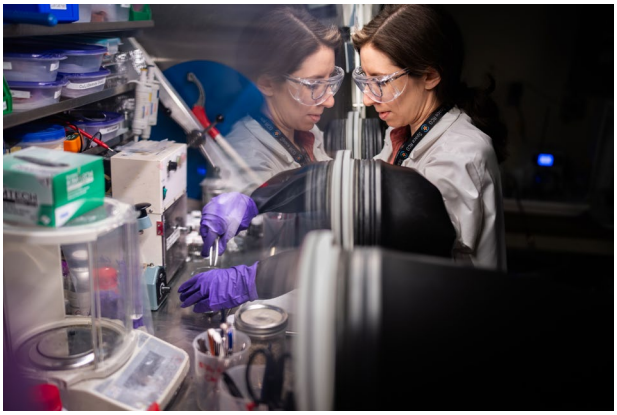
Stronger grids support data center demand **Page 8**

EMPLOYEE RECOGNITION AWARDS 2026

Mining batteries, in a microwave

Microwave-based method to upcycle old lithium-ion cathodes



IN THE HOOD — Sandia electrochemist Aliya Lapp prepares a sample of upcycled lithium battery cathode for testing. **Photo by Craig Fritz**

By **Mollie Rappe**

Instead of letting old lithium-ion batteries pile up as waste, Sandia researchers have developed a microwave-based process to recover and remake their cathodes, potentially turning spent batteries into a new domestic source of critical materials.

Lithium-ion batteries power everything from phones and electric vehicles to grid-scale energy storage and earbuds, but their cathodes — the part of batteries denoted by a plus sign — are expensive to make and rely on minerals sourced from a limited number of countries, including lithium and cobalt. The Democratic Republic of the Congo, for example, is responsible for mining about 70% of the world's cobalt.

Sandia's new method does more than recycle those cathodes: It upcycles them, transforming spent battery material into new cathodes that better

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How scientists support planetary defense by reconstructing a fireball's path using sound waves

By **Kristen Meub**

When a bright fireball streaked across the Alaska sky last spring, the usual tools scientists rely on to track such events — cameras and satellites — did not provide a detailed picture.

But the meteoroid left behind something else: low-frequency sound waves that traveled hundreds of miles and were captured by a dense network of earthquake and volcano-monitoring sensors on the ground.

Using those signals, a Sandia-led team of researchers, students and citizen scientists reconstructed the object's path through the atmosphere, where it broke apart and where debris likely fell.

In a study published in the Journal of Geophysical Research: Planets, the team showed how low-frequency sound waves, faint ground vibrations, weather radar data and publicly shared videos can be combined to reconstruct a fireball's path even when optical coverage is sparse or incomplete.

That matters for planetary defense because fast, reliable reconstruction after

— CONTINUED ON PAGE 6

ELIZABETH SILBER — Sandia physicist Elizabeth Silber uses infrasound, a low-frequency sound too deep for people to hear, and seismic data to study meteors and other fast-moving objects in the atmosphere. **Photo by Craig Fritz**

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Setting standards

Sandia helps bridge the gap between technology and human readiness

By **Kenny Vigil**

Three words piqued systems engineer Judi See's interest during a presentation at Sandia late one afternoon: human readiness levels.

"My ears immediately perked up. The speaker didn't really say anything more about it," Judi said, referring to a 2015 presentation by the National Defense Industrial Association Human Systems Division chair. "I was intrigued, so I went online and started looking up human readiness levels. The concept was first proposed back in 2010."

That curiosity eventually helped fuel the development of a national standard designed to answer a question that engineers do not always measure as early or as consistently as technical performance: Is a system ready for the people who will use it?

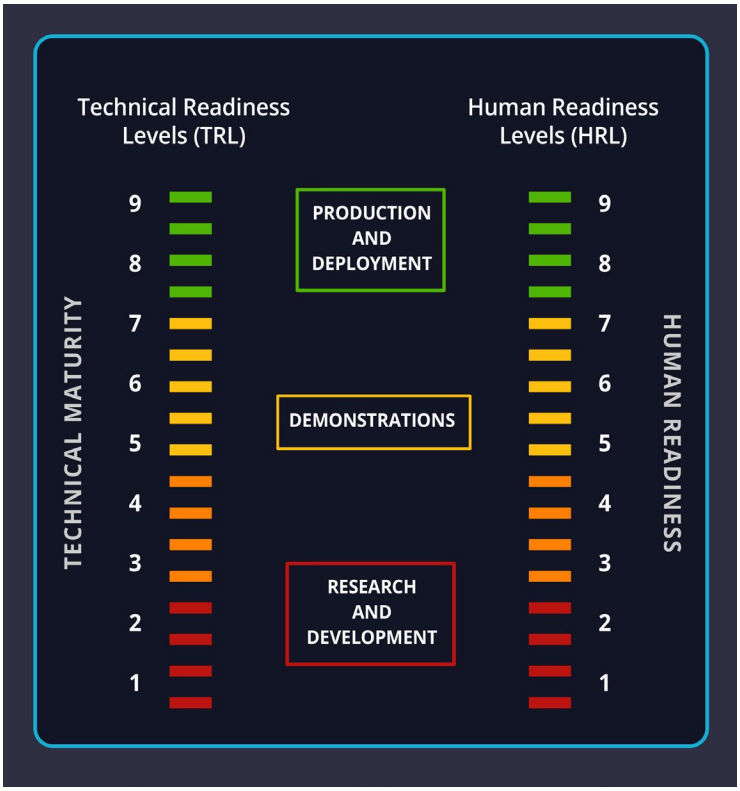
The American National Standards Institute and Human Factors and Ergonomics Society published the standard in 2021. The standard must be reaffirmed or reviewed every five years, and Judi has been collecting feedback for improvement from current users for potential updates later this year.

Big benefits

Prior to Judi's curiosity, the military

HUMAN-READY — Sandia systems engineer Judi See led an effort to develop a human readiness level scale, which federal government agencies are working to implement. The scale ensures technologies are ready for human use.

Photo by Craig Fritz



SCALING UP — Sandia systems engineer Judi See helped lead an effort to develop the human readiness level scale. The goal is to use it with the technical readiness scale so that technical maturity and human readiness advance together.
Graphic by Ray Johnson

worked on human readiness levels but not to the point of implementation.

"The human readiness level scale evaluates whether any technology under development is compatible with human limitations and capabilities," said Judi, who works in strategic analysis for nuclear deterrence. "It looks at all aspects of effective and safe human use."

The human readiness level scale, or HRL, is the counterpart to the technology readiness level scale, or TRL, developed by NASA in the 1970s to communicate technical maturity.

The HRL puts humans front and center during development of technology, instead of waiting until it's fully developed to get user feedback.

"When the design is set in stone, what you're left to do is train the user," Judi said. "Making changes later in the development cycle is costly."

Studies show big benefits when human readiness is incorporated at the beginning of technological development. It improves the overall effectiveness of that technology, improves timelines, reduces program risks and perhaps most importantly, reduces risk for human error and accidents.

Sandia study

"I proposed conducting a study on the utility of the HRL scale here at Sandia within our nuclear weapons programs," Judi said. "It got approved."

Judi completed the study and the response was clear: people involved in the weapons programs saw value in a tool that would keep the human element from becoming an afterthought.

"They thought it would have utility and it would help them think about the human in the system more consistently throughout the entire program," she said.

Shortly after she completed the study, Judi got a call from a systems engineering professor at Old Dominion University who had seen her work on the HRL scale.

"As we talked, we realized this was still conceptual," she said. "If we wanted to get something implementable like the TRL scale, we needed additional work."

Leading experts

Outside of her regular Sandia duties, Judi formed a joint working group in 2019. Others at Sandia also directly contributed to the effort.

"Maturing the human readiness scale and chairing the writing committee for the standard required a tremendous amount of work," Judi said. "I believed in its importance. Passion and vision can be great drivers. They enabled me to get other people on board, many of whom I had never even met."

More than 30 human systems experts from across the country, including those with the DOE, national laboratories, the military, industry and academia, worked to develop the HRL scale.

Mica Endsley, a former chief scientist of the U.S. Air Force, participated in the working group. "It's been a tremendous effort," she said. "It lets people understand intuitively how much work has been done."

Endsley added that when working with generals at the Pentagon and other decision-makers, they understood the TRL scale, which was implemented there in the late 1990s. "We tried to map to those levels," she said.

The TRL focuses on technical maturity and includes nine levels. Level 1 is a basic concept or idea. Level 9 means it's a fieldable technology or system. The HRL scale is intended to align directly with those TRL levels. For example, at Level 4, while the TRL scale addresses component or breadboard validation in the lab, the HRL scale emphasizes comparable human-centered lab work consisting of modeling, part-task testing and trade studies to explore candidate human systems design concepts for the technology under development.

Creating consistency

While users can subjectively say whether a technology is usable, the detailed criteria and evidence in the HRL standard enable human factors engineers to represent human readiness with a single numerical measure that anyone — across industries and across the world — will understand. In addition to standardization, the importance of documenting evidence before moving to the next readiness level on the scale is emphasized. In an ideal world, Judi said, technical maturity and human readiness advance together.

"While you're making your technical improvements, you're also at the same time thinking about the user of that technology," she said.

After about a year, the working group fully defined all nine levels of the HRL scale, established entry and exit criteria for

each level, and completed tabletop exercises to evaluate its utility for historical scenarios involving human systems issues.

Formalizing the scale

After developing and defining the nine levels of the HRL scale, the team turned its focus to formalizing the framework.

"We then decided to form a committee to turn it into a formal technical standard through the American National Standards Institute and Human Factors and Ergonomics Society," Judi said. "To take it from essentially a tested prototype to that final fieldable product took organization, dedication and persistence in the face of setbacks."

Judi said one lingering question after publication of the standard was whether any organization would adopt or implement it. That question was soon answered when the FY25 National Defense Authorization Act required the DOD to review the HRL scale as a way to enhance safety in relation to human factors.

"Seeing the military recognize the value of using the standard and officially adopting it felt like a great accomplishment," Judi said. She added that this requirement could be expanded to contractors and partners.

Pam Savage-Knepshield, a senior human factors engineer at defense contractor CACI International Inc., has applied the HRL scale to four software programs of record for Army field artillery command and control systems. She said that when used alongside the TRL scale, the HRLs help validate human performance before a system reaches the battlefield, strengthening both program success and mission readiness.

"The HRL scale is especially critical to the application of military equipment design because the stakes are high on the battlefield," Savage-Knepshield said. "Warfighters' lives and mission success demand intuitive, safe and effective equipment that appropriately accommodates and augments human capabilities and limitations. HRLs act as a security net to ensure equipment is truly battlefield-ready and optimally supportive of the personnel using it."

Promoting the scale

Endsley, the chair of the Human Factors and Ergonomics Society Government Relations Committee, has been working to raise awareness at other government agencies about the standard, and most have been receptive.

"We're promoting that the standard is best practice," Endsley said. She emphasized that the scale can be used on any technology that is under development or being considered for procurement. "Human factors need to be considered early to save money and time."

As a result of this awareness work, Congress also required the Federal Aviation Administration to review the HRL scale and standard. Judi said the FAA is currently finalizing how it will incorporate the standard into its work after completing extensive reviews.

Meanwhile, Judi is frequently invited to chair conference panels, tailor presentations and advise agencies to consider how HRL implementations can help meet their organizational goals of mission-ready, safe systems.

"I typically receive requests from organizations throughout the U.S. every year to present the human readiness level scale and the standard to their human systems groups," she said.

The Human Factors and Ergonomics Society recognized Judi in 2022 with the Oliver Keith Hansen Outreach Award for her work on the HRL scale.

Battery recycling

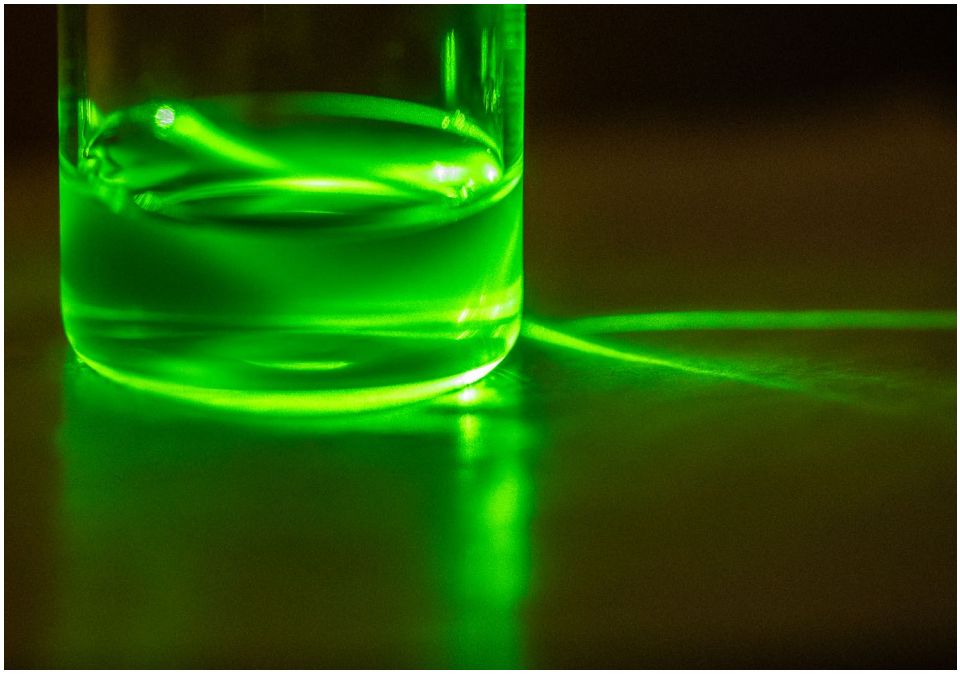
CONTINUED FROM PAGE 1

match current industry needs while using less time and being more affordable than conventional high-temperature approaches.

"Cobalt is a critical material for almost all consumer electronics," said Clare Davis-Wheeler Chin, a Sandia nanomaterials chemist and an inventor of the method. "Since there's only one main source of cobalt, it would be very easy for the cobalt supply chain to just disappear. We're about to have an abundance of old EV batteries that are either going to go to the landfill or that we can mine to develop a domestic supply."

Opening cathodes in a microwave

In a battery, the cathode is the positive electrode, where lithium ions meet electrons from outside the battery.



SCATTER SHOT — A vial of nanosheets formed from lithium battery cathodes in water by Sandia's battery upcycling method. The scattered light from a green laser indicates that the cathodes have been successfully broken down into nanosheets. **Photo by Craig Fritz**

MASTER MICROWAVE — Sandia nanomaterials chemist Clare Davis-Wheeler Chin loads a sample of cathode material into a microwave reactor to open it up into tiny layers called nanosheets.

Photo by Bryn Whisenand

Using a microwave reactor — similar in size and power usage to a household microwave oven but more adjustable — and a large positively charged ion, the researchers can open old cathode powder into tiny layers called nanosheets. The large positively charged ion is akin to the active ingredient in hair conditioner.

Microwaves are very efficient at heating water, Clare said. Additionally, the uneven heating that can be frustrating when warming leftovers turns out to be beneficial when breaking down cathode materials.

The microwave method cut the time needed to turn powdered lithium cobalt oxide, the most common cathode material from old lithium-ion batteries, into nanosheets from seven days to two hours, Clare said.

Kirsten Jones, a former Sandia intern and doctoral student at the University of New Orleans, was involved in developing the microwave method. The new method turns 95% of the material into nanosheets, compared with 60% previously.

Of course, batteries aren't designed to be taken apart and mined, so there was significant work involved in getting cathodes out of old batteries and into a usable powder. That turned out to be more of a challenge than anticipated, said Kevin Leung, a Sandia computational materials scientist who led the Laboratory Directed Research and Development research team. This disassembly work was led by materials scientist Bryan Wygant using expertise from Sandia's Battery Abuse Testing Laboratory.

Other methods for upcycling old lithium-ion battery cathodes are being explored, especially at Argonne National Laboratory's ReCell Center, Clare said.

"There are other DOE labs working on battery cathode recycling," Kevin added. "We just have a different way of doing it. ReCell's way of tweaking the cathode composition is pretty much the same way industry makes the cathode material in the first place, which involves putting everything in an oven and heating it to a high temperature. Our approach will enable low-temperature processes that avoid using so much energy."

Swapping out cobalt for nickel

Why nanosheets?

"When you have nanosheets, ion exchange can access the entire sheet and you can maximize the amount of critical materials that can be exchanged," said Aliya Lapp, a Sandia electrochemist with expertise in galvanic ion exchange.

That matters because nanosheets are easier to work with, allowing scientists to swap metal ions within the material to keep up with industry trends, Clare said. For example, the auto industry has found better cathode performance after substituting some of the expensive cobalt with cheaper nickel, Kevin said.

"This is important because by the time we're recycling one of these cathodes, 10 to 15 years have passed since it was made, and industry trends can change dramatically in that time," Aliya said. "This ensures that the cathodes we produce match current trends."

Additionally, the nanosheet method automatically fixes microscopic defects in the cathode material created over years of use and even removes impurities, Clare said. Existing methods of cathode recycling cannot "heal" these defects without many additional steps.

The cobalt removed from the nickel-substituted cathode can then be captured and used in an additional cathode, effectively producing two new cathodes from one old one, Aliya said.

Anastasia Ilgen, a Sandia geochemist, developed a metal organic framework

An opportune internship

Kirsten Jones, a doctoral student at the University of New Orleans, was a Sandia intern who helped develop the microwave-based method to open old lithium-ion battery cathodes into tiny layers called nanosheets.

Jones was interested in doing an internship during graduate school and wanted to explore a career at a national lab. So, when Clare Davis-Wheeler Chin reached out to Jones' current adviser, John Wiley, a former advisor of Clare's, about the research project, it was a perfect match.

"I really wanted to do an internship, and I knew a career opportunity I wanted was to work in a national lab, so what better way than to do an internship at a national lab?" Jones said. "I had talked to people from national labs and the work-life balance they had and the projects they got to work on were really cool."

Jones came to Sandia September 2023 to do research on Kevin Leung's Laboratory Directed Research and Development project. She worked on the project for three months onsite at Sandia and then continued the research from Wiley's lab in New Orleans until September 2025.

Jones' time working at Sandia only solidified her interest in working at a national lab after she completes her Ph.D., she said.

"My favorite part was meeting everyone and learning what they do," Jones said. "Seeing the collaboration and how well we all worked together and bounced ideas off of each other — that's my favorite part. I'm extremely grateful for the experience and how everyone went out of their way to make me feel comfortable."

-based method to selectively capture the swapped cobalt from the reaction mixture.

In fall 2022, Kevin conducted computer simulations to see whether exchanging metal ions would even be possible. The density functional theory calculations showed that the swap would not be spontaneous but wasn't too unfavorable or too slow, he said.

Then the team led by Candace Chan, a professor at Arizona State University, conducted proof-of-concept ion-exchange experiments. Using several methods, they showed they were able to swap out about one-ninth of the cobalt for nickel. Aliya joined the project later and provided guidance on ion exchange as well as on the most feasible and economically viable paths for upcycling cathodes.

Technology development underway

In spring 2025, Clare and Kevin participated in the DOE's Energy I-Corps training program to further develop their microwave "mining" method into a technology. As part of the program, they interviewed 80 industry leaders in battery recycling to better understand industry challenges and the market environment, Clare said.

Aliya is working on improving the ion exchange in addition to a technoeconomic analysis of the method. A key challenge is ensuring that the cathodes created from mining old batteries are cheaper than importing new cathodes or cathode materials from other countries, she said. Preliminary analysis using an economic modeling tool developed by Argonne suggests that this method has the potential to increase cathode recycling profits by at least 30% compared to state-of-the-art recycling methods, she added.

The technology was submitted to the R&D 100 Awards this year. The team has filed two patents on the technology and is actively seeking industry partners for cooperative research agreements, licensing and Technology Commercialization Fund proposals.

"This method could also be extended to other types of battery cathodes such as sodium-ion batteries or zinc-ion batteries," Aliya said. "As long as the cathode material is a layered intercalation compound, our method will work. This is a fantastic technology with a lot of potential."

The researchers are continuing to refine the process, including improving the ion exchange and studying the economics of the approach. Still, the early results suggest old batteries could become more than waste. With further development, they could become a valuable domestic resource for the next generation of energy storage technologies.

The research was funded by Sandia's LDRD program. The technology development was supported by the Energy I-Corps program.

Fireball path

CONTINUED FROM PAGE 1

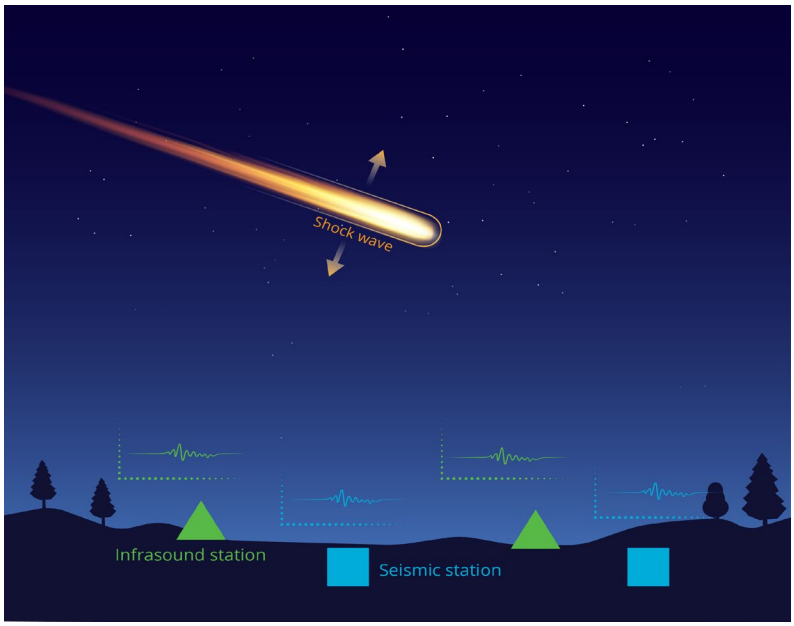
an atmospheric entry event can help scientists determine what happened, where debris may have fallen, its origin and whether there are any potential hazard implications. The research, funded by the Defense Threat Reduction Agency, is part of a broader effort to improve post-event assessments of objects entering Earth's atmosphere, including both natural fireballs and space debris.

A signal that didn't look like an earthquake

The investigation began the same day as the fireball itself. Logan Scamfer, then a research assistant at the University of Alaska Fairbanks, started looking into the signals appearing in the region's seismic data. An analyst from the Alaska Volcano Observatory shared recordings of an unusual acoustic signal that appeared among the usual seismic data the sensors record.

Logan started pulling up more stations across the region, and the same signal kept appearing. He then checked data from a sensor array south of Anchorage and found a clear N-wave, a shape often associated with decayed shock waves. He began to suspect the signals came from a meteor.

By late afternoon, news reports began circulating about a fireball seen over Alaska, confirming his initial suspicion about the source of the signals.



SENSOR FOOTPRINT — The fireball generated low-frequency sound waves that traveled hundreds of miles across Alaska. A total of 57 different earthquake and volcano-monitoring sensors recorded signals, giving the team enough data to begin reconstructing the fireball's path, even without the kind of optical record scientists would normally hope to have. **Graphic by Vickie Aranda**

About a month later, Logan arrived at Sandia for his summer internship with physicist Elizabeth Silber, whose research focuses on using infrasound, a low-frequency sound too deep for people to hear, and seismic data to study meteors and other fast-moving objects in the atmosphere. Because this fireball wasn't clearly

detected by satellites or all-sky cameras, the pair decided to explore whether infrasound and seismic signals could be used to learn more.

"I had already planned to intern at Sandia, and I knew Elizabeth was an expert in meteor science, specifically when it comes to seismoacoustic signals from fireballs," Logan said. "I shared my findings on this event with her, and it eventually became the main focus of my internship."

He and Elizabeth started by looking for every seismic and acoustic signal they could find.

Elizabeth said the challenge — and the opportunity — was that this was not a planned measurement campaign with cameras and sensors already positioned in advance. The team had to rebuild the fireball's flight from whatever data existed.

Elizabeth's previous work recording and characterizing the infrasound and seismic waves generated by NASA's OSIRIS-REx capsule reentry in a large, highly instrumented 2023 study helped inform the team's study of the Alaska fireball.

"Listening" for a fireball

When a meteoroid flashes across the sky, it generates a powerful shock wave similar to a sonic boom but produced high in the sky and often along a long path. As the shock wave spreads, it can turn into infrasound. Some of that energy might also transfer into the ground. When the pressure waves reach the ground, they can create tiny vibrations that register on earthquake sensors.

"Alaska is exceptionally well-instrumented with infrasound and seismic stations because these systems are widely used for monitoring earthquakes and volcanic activity," Elizabeth said. "That infrastructure also records the pressure waves and coupled ground motion produced when a meteoroid generates shock waves during hypersonic entry."

In total, 57 instruments picked up the Alaska fireball, including 37 seismic stations, 16 infrasound sensors and four infrasound sensor arrays. Some detected the event from about 360 miles away. That broad sensor footprint gave the team enough data to begin reconstructing the fireball's path, even without the kind of optical record scientists would normally hope to have.

Using those ground recordings, the team rebuilt the fireball's flight path, identified where it broke up and narrowed down where the debris likely fell. They shared the approximate location with a colleague at NASA, who used Doppler weather radar to search for and find the signature of falling debris. The radar doesn't typically "see" the luminous fireball itself, Elizabeth said. Instead, in some cases, it can detect radio waves bouncing off the debris cloud as pieces fall.

DATA READINGS — Year-round intern Logan Scamfer checks data recorded by a ground sensor in Alaska. **Photo courtesy of Logan Scamfer**

The team then compared its sensor-based reconstruction with observations from dashcam and security camera videos shared by citizen scientists. They used calibration images of the night sky to help determine viewing geometry from the videos. Together, those independently gathered clues helped the researchers test and refine their reconstruction.

Combining the ground-sensor data, radar clues and video analysis, the team estimated the meteoroid entered Earth's atmosphere at a shallow angle of about 19 degrees and traveled roughly 50,000 to 56,000 mph — fast enough to cross the United States in roughly three minutes. The team also estimated the event released energy equivalent to about 38 tons of TNT.

Reconstructing the flight path allowed researchers to estimate the object's orbit around the sun before it hit Earth's atmosphere, suggesting it likely came from the main asteroid belt. That is where many rocky objects in the solar system originate, making it a plausible source for this kind of meteoroid.

To the team's knowledge, this was the first time scientists were able to locate signatures of meteorite debris on radar based only on guidance from seismoacoustic data. That distinction points to a promising new way to narrow down debris fall zones after future events, especially in places where visual observations are limited.

"My internship has been great, and I've been lucky to learn so many new things while being here," Logan said. "Learning more about meteor science, as well as getting hands-on experience with infrasound propagation modeling, has both advanced my skill set and opened up new interests that I didn't know I had."

Faster answers

Because the event occurred in daylight and at high latitude, it was difficult to capture clearly with traditional high fidelity optical systems. The study showed that infrasound and seismic data can help fill those gaps, giving scientists a practical way to reconstruct fireballs after the fact.

"For planetary defense, infrasound and seismic data provide rapid, accurate post-event characterization," Elizabeth said. "These reconstructions strengthen the ability to assess what happened, where and with what potential hazard implications soon after an event occurs."

As data-center demand grows, Sandia advances AI controls to keep voltage steady in real time

Technology could help protect critical defense and national security infrastructure during disruptions and attacks

By **Kristen Meub**

As artificial intelligence drives rapid growth in data centers, utilities are facing a new challenge: keeping voltage steady as electricity demand grows, shifts quickly and becomes harder to predict. As demand grows and more distributed energy resources such as batteries, rooftop solar and backup generators come online, utilities have more moving pieces to coordinate and less margin for error in keeping voltage steady for critical loads.

DASHBOARD VIEW — In Sandia's Distributed Energy Technologies Laboratory, engineer Rachid Darbali-Zamora reviews the DERMS control dashboard used to coordinate grid-connected devices such as inverters, batteries and solar resources. The AI-enabled controls are being tested to improve voltage regulation and power quality for sensitive loads. **Photo by Craig Fritz**

A Sandia team is working to help manage voltage and support a resilient grid with AI-driven controls that can respond in real time to fluctuations in electricity demand and supply. The work has moved from computer simulation to laboratory testing with real grid hardware and field demonstrations at two sites in Lubbock, Texas. The same approach could be applied to strengthen power resilience for critical defense infrastructure.

"The way we generate electricity and the loads being placed on the grid are evolving, but the backbone of the grid that connects these is staying the same," Sandia engineer Rachid Darbali-Zamora said. "We need more control to ensure everything can be integrated into the grid in a more reliable manner. A key goal is keeping voltage within operating limits as conditions change from second to second."

Reliable electric power is also a national security issue, especially for critical infrastructure at home and abroad.

"In scenarios of national conflict or war, adversaries will target energy infrastructure to disrupt both military and civil functions," senior manager Charlie Hanley said. "The Sandia-developed DERMS system helps to defeat such adversarial attacks through the application of agile and secure technologies that adapt to real-time developments and keep critical systems — and mission functions — operating. Sandia's deep understanding of related threats, vulnerabilities and mitigations gives us the unique capability to design and test such AI systems in real settings, thereby providing technology solutions to address critical issues of national security."

While frequency is typically managed at the bulk power system level, distribution grids need fast local voltage regulation to maintain power quality for sensitive loads. For defense and other critical infrastructure, maintaining power quality can be as important as maintaining power itself.

A new kind of grid control for resilience and continuity

Traditionally, utilities manage voltage by installing or upgrading equipment such as capacitor banks and line voltage regulators.

"Those are traditional, conventional devices that are more mechanical — switching on and off," Rachid said.

Sandia's approach aims to provide more continuous, coordinated voltage support by using hardware and capabilities already built into many grid-connected devices. Those devices include inverters, which connect resources such as solar panels and batteries to the electric grid to provide

steadier voltage and improved power quality. By coordinating many devices at once, the controller can respond quickly to disturbances, including those caused by deliberate disruption of energy infrastructure.

"To provide these services, we're leveraging inverters that are already in the grid," he said. "That means the utility doesn't have to make as many upgrades. It can also reduce reliance on slower, mechanical switching when the grid is under stress."

The software platform is a distributed energy resource management system, or DERMS, which forecasts changes in electricity use and available power, coordinates grid-connected devices and automatically responds to disturbances to support a more resilient grid. AI helps the controller coordinate device actions in near real time while respecting equipment limits and operating constraints.

"Our team wanted to deliver something that is powerful and intelligent, but also realistic for utilities to adopt," Rachid said. "AI helps us make sense of all the moving pieces on a modern distribution grid and do it in real time."

Testing AI controls against real-world disturbances at Sandia's Distributed Energy Technologies Laboratory

Rachid said the team started with a basic premise: One-size-fits-all grid controls don't work everywhere.

"Every location is unique," he said, with different hazards, critical services and mixes of grid-connected resources.

To create a controller that can coordinate devices and adapt to local needs, the researchers first built and tested their approach in simulation before validating it with real hardware.

The next step took place at Sandia's Distributed Energy Technologies Laboratory using a method called power hardware-in-the-loop, or PHIL. This method lets researchers connect real grid equipment, such as commercial power inverters and battery hardware, to a real-time grid simulation. The setup makes it possible to test how control software performs under realistic conditions without connecting to the actual electric grid. This kind of test-and-iterate validation is especially important for national security applications, where controls may need to perform through rapidly changing conditions and adversarial disruptions.

In the lab experiments, the team linked the AI-driven controls to commercial inverter hardware and other grid-connected devices while a digital real-time simulator created changing grid conditions. This enabled researchers to evaluate how quickly the controller could respond to rapid shifts and disturbances, including the kind of voltage swings utilities work to prevent. The tests also challenged the controller with fast-changing scenarios so the AI could update coordinated setpoints as conditions evolved.

GRID CONTROL — Sandia researchers Rachid Darbali-Zamora and Miguel Jimenez-Aparicio tested AI controls on a microgrid at Texas Tech University. The test demonstrated the system's ability to manage energy flows in real time.

Photo courtesy of Sandia

The lab tests served as a reality check before field deployment. Rachid said computer simulations can miss communication issues that show up when software exchanges data with real equipment.

"Simulations capture dynamics, but they don't really capture, for example, communication challenges," he said.

By testing with real hardware in the loop, the team could see whether the controller still performed well when messages arrived late or data links slowed.

"These experiments were critical," Sandia researcher Jon Berg said. "They allowed us to evaluate how the system behaves with real hardware, not just models. That gives us and our partners confidence that the technology is ready for real-world deployment."

From lab to field demonstrations

After validating the controls in the lab, the team tested the system at two sites in Lubbock: Sandia's Scaled Wind Farm Technology facility, known as SWiFT, and the Texas Tech University GLEAMM microgrid.

At SWiFT, the researchers connected the DERMS controls to operating equipment to see how the controller performed under real-world conditions as system conditions changed. Demonstrating performance on operating equipment helps build confidence for future use at mission-critical sites that cannot tolerate extended downtime.

The team then deployed the software platform at the GLEAMM microgrid, which includes a data center. There, the controller coordinated grid-connected devices in real time to help keep voltage steadier and maintain power quality for critical loads.

To measure impact, the team ran side-by-side field tests with the controller turned on and off.

"We ran an entire day with the controller and an entire day without the controller," Rachid said. "When you compare the voltage graphs from those two, you can visually see that the voltage in the system is improved with the DERMS controller."

At the site, voltage typically runs about 5% above normal, and the coordinated controls helped bring it closer to the value utilities aim to maintain.

For utilities and microgrid operators, that kind of control could help manage a more complex distribution grid without relying only on slower mechanical equipment or major infrastructure upgrades. For national security purposes, it can also provide an additional layer of resilience by enabling agile response as conditions evolve during an emergency or deliberate attack.

"These demonstrations prove that AI can meaningfully improve how microgrids and distributed resources operate," Sandia researcher Miguel Jimenez-Aparicio said. "The field data reinforces what we observed in PHIL testing. This technology can deliver

real benefits to utilities, communities and critical infrastructure."

Accelerating the path to deployment with Energy I-Corps

Now that DERMS has been tested successfully in the lab and demonstrated in the field, the team is also working to move the software toward real-world use.

The project was selected for the DOE Energy I-Corps Phase II program, which connects researchers with potential users to better understand operational needs and identify features that would make the tools practical to deploy.

Through interviews with utilities, microgrid developers and industry partners, the team gathered feedback on what organizations need most: tools that make it easier to coordinate grid-connected devices and integrate new equipment without adding major operational burdens.

Building on that progress, the project was recently accepted into Energy I-Corps Phase III, a competitive follow-on effort aimed at accelerating commercialization and supporting additional field deployments with partners.

"Our Energy I-Corps experience made the impact of this work even clearer," Sandia researcher Jorge Leon-Quiroga said. "Utilities want solutions to complex problems using intelligent tools. By pairing Sandia's technical capabilities with customer insights, we're positioning this technology to make a meaningful difference in the evolving energy landscape."

The work also reflects what the DOE's Genesis Mission is designed to accomplish: apply AI to tackle the nation's most complex science and technology challenges. By combining AI-enabled coordination, hardware-in-the-loop validation and field demonstrations, the team is expanding a repeatable capability for designing and testing agile grid controls that can help defeat disruptions and keep critical systems operating.

Sandia creatives present their work at Art Fest

ART AND CONNECTION — Labs Director Laura McGill, left, connects with staff members during Art Fest. **Photo by David Lienemann**

By **Auri Atencio**

On May 11, Sandia hosted its annual Art Fest, where on-site and remote employees gathered to enjoy diverse creative talents beyond the lab. Featuring submissions from every division, the event highlighted how creativity fuels not only artistic expression but also scientific discovery and problem-solving.

The in-person reception offered opportunities for leadership to engage one-on-one with staff in a relaxed setting.

"While it was a brief moment, it was wonderful to meet the Labs director, talk about art and have a comfortable conversation where the usual formal barriers seemed to dissolve," said featured artist James Park, potter and systems engineer. "Unlike typical interactions within the lab, which can sometimes feel framed by an invisible wall of protocol and hierarchy, our shared appreciation for art fostered a more open and genuine exchange."

Groups that presented booths at the event emphasized the connection between art and brain function, emphasizing how creative expression enhances cognitive abilities and innovation, qualities essential to Sandia's mission. Groups included the Employee

EUBANK SUNRISE —Cross-stitch by mechanical engineer Carol Young.

Assistance Program, Leadership and Organizational Development, and the Super Workforce Improvement Network initiative, which is focused on employee well-being and professional growth.

Voted favorites

Sandians voted for their favorite pieces, selecting three award-winning artists from the impressive lineup.

"Eubank Sunrise" by Carol Young, mechanical engineer. Carol's cross-stitch is a recreation of a sunrise she witnessed while stuck in stopped traffic at the Eubank gate, capturing the unexpected beauty found in everyday moments and reframing a frustrating experience into inspiration.

"Sandia Sunset" by James Park, systems engineer. James's pottery work draws inspiration from the simple joy of a chocolate vanilla ice cream swirl topped with whipped cream, strawberry syrup and a cherry on top. "Food is life. I live to eat and eat to live," James said.

His work evokes New Mexico landscape through subtle color blending.

"Popped No. 5" by Katie Jurney, test director. Katie's oil painting is part of a five-work series that marries her professional world with her passion for creating. As a test director for the Kauai Test Facility, the series helped Katie return to the fundamentals of oil painting while sharing what she loves most about her work. "The feeling of T-0 during a launch is unmatched," she said, capturing the anticipation and energy of that moment in her mixed-media creations.

These artists stood out among 154 submissions, which represented rich artistic diversity within Sandia's workforce. Organizers combined the in-person reception with a virtual gallery to include employees across locations and roles. The event offered a combination of creativity and connection that showcased the artistic talents of the workforce and strengthened Sandia's culture of collaboration.

POPPED NO. 5 — Oil painting by Katie Jurney.

SANDIA SUNSET — Pottery by systems engineer James Park. **Photo by David Lienemann**

EMPLOYEE RECOGNITION AWARDS 2026

Labs Director's Award winners showcase innovation, teamwork and mission success

By **Lara Adams**

Eric Markham saw a way to make a process more cost efficient, so he set out to improve it and saved Sandia $8.3 million.

Working with key stakeholders across the Labs, Eric established a recycling program that captures and refines Sandia's scrap metals. This process will continue to save Sandia millions of dollars annually and earned him an Individual Labs Director's Award for Innovation during this year's Employee Recognition Awards ceremony in New Mexico.

"(The recycling program) set a new standard for sustainable resource management here at Sandia. It reflects the Laboratories' commitment to innovation, collaboration, fiscal responsibility — a lot the things we've heard the Labs director talk about," Eric said.

Eric insists that while he received an individual award, "no one person does anything in a box here at Sandia. It really takes a team. There was a huge group of people that really went into this being successful."

Eric's recycling program, along with a crash test, a high-stakes technical analysis, two large-scale workforce reshaping efforts and an urgent multidisciplinary response to a component structural failure represent the breadth of what makes Sandia a premier national laboratory, said Labs Director Laura McGill.

"Their accomplishments span organizations and disciplines, but they share a commitment to excellence, service,

HIGH-FIVE — The W80-4 Warhead Case Anomaly Resolution Team earned a public congratulations from Labs Director Laura McGill during a May 28 event in Livermore for the work that earned them an Employee Recognition Award and Labs Director's Award. **Photo by Spencer Toy**

INDIVIDUAL HONOREES

Amanda Peretti
Anthony Garland
Christian Trott
Dianne Hall
Eric Markham*
James Lewis
Jarod Wallace
Jennifer Galasso
John Russell
Melissa Revelle
Michael Denning
Paul Kuberry
Phillip Aragon
Robert Reyna
Roberta Rivera
Robin Blume-Kohout
Stephen Martelli
Taylor Bridge
Tucker Haydon
Victoria Zheng

*Labs Director's Award

NUCLEAR DETERRENCE

- Pressure Delta-Volume II Team
- Plutonium temperature measurements at relevant conditions on Z
- W80-4 Detonator Stronglink Team
- Digital Transformation Policy Working Group
- Explosive Materials Operations LIMS Team
- B61-13 Qualification and FPU
- Legacy Chemical Reduction Team
- Blue Laser Welding for National Security Cable Design - Development and Operations Team
- Rapid Development Connectors
- Aleph Plasma Physics Team
- Shock Mitigation Innovation Team
- Atrax Payload Team
- SLCM-N/W80-5 Transformative Weapon Design and Cost Report
- W87-1 Anomaly Resolution Team
- W88 ALT 370 System and Arming, Fuzing and Firing Last Production Unit Teams
- Mobile Guardian Transporter Prototype Two Crash Test Fielding Core Team
- Controlatron Problem Solving
- ACRR Radiation Effects Team: Pioneering Collaborative Research in Assessing Materials and Electronics Performance in High-Radiation Environments
- ECSE - ASD Scorpius Injector Build and Test Team
- IPO-led Technology Commercialization Fund Project Team
- Design Definition Improvement

teamwork and mission impact," Laura said. "The common thread is that their contributions strengthened the Labs and better positioned us to serve the nation."

Laura presented four Labs Director's Awards at New Mexico's ERA ceremony at Regal Winrock Theaters and Winrock Park on May 14 and two awards at California's ceremony at Garre Vineyard & Winery Event Center on May 28.

Winning teams

From the 20 individuals and 83 teams who received ERAs this year, each division selected one honoree to nominate for the Labs Director's Award. From there, Laura McGill selected Labs Director's Award winners based on their impact on Sandia's success and future.

"The people and teams selected for these awards conducted excellent work and made a meaningful difference to Sandia and the missions we serve," she said. "They solved difficult problems, brought people together across organizational boundaries and found new ways to move important work forward."

BIG SCREEN SUCCESSES — Employee Recognition Award winners arrive at the Regal Winrock Theater for the award ceremony in New Mexico. This unique venue offered a fun and "regal" atmosphere for the annual event. The Labs Director's Award portion of the awards ceremony was held at Winrock Park after the division awards. **Photo by Craig Fritz**

EXECUTIVE SUPPORT DIVISION

- Quantum, Computing, Mathematics, and Physics Camp Planning and Execution Team Tadpole

DIVISION 3000

- Workforce Shaping Efforts*
- The Foreign National Networking Group and IT initiative
- Sandia Parents Group and Partners Delivering FY25 Ethics Training Scenarios and Support to Management and Staff
- Safety Culture Cultivators
- Onboarding Transformation Team
- Core EHR Implementation Team

*Labs Director's Award

DIVISION 4000

- Putting "Express" back in Facilities Express
- Power Sources Capability Critical Decision Approval and Project Execution Team
- Flight Line, Restricted Area Badge Access Program
- Sandia NM Sitewide Environmental Impact Statement Team
- Sandia Recommissioning Team
- Integrated Division 4000 3D Printer Indoor Air Quality Assessment
- The D4K Show
- Quality Assurance Program Plan for Sandia
- The Programmatic Infrastructure Program

DIVISION 5000

- Mufasa Integrated Review Team*
- EESD Cold Bias Instability Deviation Anomaly Resolution Team
- SANDBEE
- Skyfox
- Sandia Space Cyber Collaboration Team
- Garrix / Dreamer
- MESA Extended Life Program Tool and Equipment Team
- QOGENT Core Team (Stage A)
- FTX-40 Astrotech Space Operations Team
- Field Intelligence Element Iceberg Cybersecurity Inspection
- Curious Melody Bi-static AWSAR Radar Integration and Flight-Testing Team

*Labs Director's Award

DIVISION 6000

- Mobile Guardian Transporter Prototype Two Crash Test Leadership Core Team*
- Global Burst Detector Mission Requirements System Verification Reviews Team
- Accident Response Query System
- Discrete State Machine Signal Integration Team
- United States Nuclear Detonation Detection System Build 7 Critical Design Reviews
- Nuclear Emergency Support Team Artificial Intelligence Thrust
- Red Door Program Development Team
- Modern Agile PIDAS Team

*Labs Director's Award

The Mobile Guardian Transporter Prototype Team, nominated for Collaboration, completed a complex system-of-systems crash test at Sandia's 2,000-foot rocket sled track, providing valuable data to verify the over-road transporter can safely and securely transport nuclear weapons, materials and systems. The test involved more than 200 people from Sandia, NNSA, Los Alamos National Laboratory and Lawrence Livermore National Laboratory.

"Receiving the award really speaks to the scale of the collaboration effort between many programs and stakeholders and highlights Sandia's ability to partner together to serve the mission," team representative Jason Berger said. He noted it was exciting and impactful that Laura McGill sees the work as one of the most important things happening right now at Sandia.

The Mufasa Integrated Review Team demonstrated Technical Excellence when asked to advise on Space Rapid Capabilities Office on the design of the Space Force's Satellite Communication Augmentation Resource program and BADGER antenna system. In a short period of time, the team was able to provide a detailed technical analysis that helped the sponsor make critical decisions. The team's implemented

WORKFORCE SHAPING — Labs Director Laura McGill presents Workplace Shaping Efforts Team representative Annie Garcia with the Labs Director's Award for her team's collaboration. **Photo by Craig Fritz**

HARDCASES — Members of the W80-4 Warhead Case Anomaly Resolution Team received their Labs Director's Award and Employee Recognition Award during the May 28 ceremony in Livermore. **Photo by Spencer Toy**

recommendations saved the government more than $10 million.

Team representative Ken Plummer applauded the team's dedication, noting their pride in providing exceptional service in the national interest.

"When Laura announced the winners, just hearing the absolutely incredible breadth and depth of the other projects, it's extremely humbling to see that this project was picked as a representative of excellence at Sandia," Ken said.

The W80-4 Warhead Case Anomaly Resolution Team jumped into action when a structural challenge was identified that could have delayed the W80-4 program. A team of multidisciplinary experts quickly came together to find the cause, redesign the part and make sure it could be manufactured while leaders secured funding and coordinated efforts to keep production moving. As a result, the schedule was back on track, the design was improved, no further failures occurred and inspection processes were standardized.

The **Division 8000 Workforce Shaping Team**, nominated for Collaboration, proactively addressed an emerging funding challenge by developing processes to identify risks and support both staff and management. Their initiatives, which were adopted organization-wide, were celebrated at the California Employee Recognition Awards event on May 28. The Human Resources Business Partner team played a crucial role in managing staff reductions and providing essential support during a period of unprecedented uncertainty. At the Livermore celebration, Laura praised the ingenuity of the team to perform this sensitive work with grace and compassion.

The **Workplace Shaping Efforts Team**, also nominated for Collaboration, initiated restructuring to align Sandia's workforce with changing mission priorities. The result was a 1% to 3% reduction that minimized employee impact and preserved essential work. The collaboration across HR, Legal, Communications, Finance, IT, Security, Payroll, Property Management and Accounts Receivable reflected Sandia's culture and the strength of teamwork.

Team representative Annie Garcia emphasized the power of collaboration in the success of this project. "It took a village to get this done," she said. "I think it really is this kind of power of the collective where everybody's discipline is needed to make this full puzzle fit together and work. That's why it's really important for us to be able to come together and recognize that this is one lab and we're all making a difference."

DIVISION 8000

- W80-4 Warhead Case Anomaly Resolution Team*
- Division 8000 Workforce Shaping Team*
- Sandia-Los Alamos Cosmic-Ray-Induced Terrestrial Neutron Test Campaign for Nuclear Deterrence, Strategic Partnership and Microelectronics
- HEARTHSTONE Phase 1 Delivery Team
- W80-4 Systems Joint Test Assembly Team
- Weapons Engineering Science and Technology Complex Predesign and Procurement Work
- Threat Focused Reverse Engineering
- Gas Analysis Surveillance Investigation
- W80-5 Feasibility Study #2 Execution Team
- GriDNA - Protecting the Grid with Artificial Intelligence through Neural Network Cyber-Physical Attack Detection
- Sandia's Pioneer Wave Energy Conversion Team
- Energy Mandate Mavericks
- Source Physics Experiment Phase III Corehole Instrumentation Team

*Labs Director's Award

DIVISION 9000

- The OneNNSAccess Initiative Project
- HR Systems Voluntary Separation Program and Government Shutdown Implementation
- Degraded Core Coolability (DCC) Disposition Team
- Enterprise Research Network Team
- SandiaAI GenAI Team
- High-Performance Computing Power Distribution Electrical Safety Response Team

DIVISION 10000

- Procurement Taxonomy Agentic AI Solution Team
- Voluntary Separation Program Integrated Operations Team
- Financial & Operations Continuity and ND Portfolio Planning Team – Sustaining Lab Operations Through Federal Turbulence
- Purchase Requisition Implementation Team
- Cost and Schedule Analysis Development Team
- W87-1 Systems Project Management Baseline Replan Team
- Financial & Operations Continuity & ND Portfolio Planning Team – Sustaining Lab Operations Through Federal Turbulence

DIVISION 11000

- CLIN 0003

Award-winning research takes a deep dive into microplastics

Sandia chemist takes home prize at the National Lab SLAM

By **Magdalena Krajewski**

When Sandia chemist Samantha Kruse stepped on stage at the National Lab Research SLAM, she asked the audience to join her in taking a deep breath. As they exhaled, Samantha said, "Over the next three minutes of this presentation, you will inhale roughly 150 individual microplastics."

The crowd laughed.

"I wasn't expecting a laugh," Samantha said. "In my head, this was a pretty serious issue; I wasn't trying to be funny. But when they laughed, I thought, 'OK, let's keep going.'"

She was one of 17 early career scientists competing at the SLAM on April 15. The presenters had three minutes and one slide to showcase their work to an audience of more than 200 policymakers, congressional staff and laboratory representatives on Capitol Hill, plus over 2,000 viewers who tuned in online to watch the livestream.

Samantha took home the award in the Advanced Materials category for her talk, "Deep dive: Revealing the 3D chemistry of microplastics."

Deep dive

The conversation around microplastics and the dangers they pose to humans and the environment is nothing new, but Samantha's research takes a deeper dive into the subject — examining the chemicals that exist within the microplastic itself and where those chemicals are located.

"We don't have a great understanding of what we're exposed to when we inhale microplastics because microplastics are not just pristine polymers," Samantha said. "In many cases, microplastics have already been in the environment for months, even years, absorbing harmful pollutants and chemically reacting, which increases their potential toxicity.

"When humans are exposed to microplastics, they're exposed to all of those additional chemicals too."

Samantha is working to identify what those chemicals are and where they exist within the microplastic, because, as she said, "Depending on where different pollutants are located inside a microplastic dictates how easily they can be released back into their surroundings, which includes the human body."

GOING DEEPER — Samantha Kruse said she is deeply vested in learning more about what the contaminants inside microplastics mean for our health and environment. **Photo by Craig Fritz**

Let them eat cake

At Sandia, Samantha is developing a method that combines current analytical techniques — which look at high-fidelity spatial and chemical information separately — into one process that she says will improve data quality while saving time and money.

Using an already well-established technique known as Matrix-Assisted Laser Desorption Ionization, or MALDI, and applying a coating of variable thickness, Samantha is able to carefully remove a small sample from a single microplastic to find out what it's made of.

"The technique I'm working on lets me control how deep the laser goes into the microplastic, so I can create a 3D picture showing where different chemicals are inside it. When I connect this process to an instrument called a mass spectrometer, I get very detailed information about the chemicals present," Samantha said in her SLAM presentation.

"By looking at the microplastic layer by layer, this method shows which chemicals are near the surface, which are deep inside and which are in between. This helps scientists quickly and thoroughly identify harmful substances in microplastics and understand where they are located. Ultimately, this work will improve our knowledge of the risks microplastics pose to health and the environment."

Samantha uses a cake analogy to simplify the concept.

"Think of frosting on a cake," she said. "You have one fork you're going to use to eat from two different cakes. One cake has a thin layer of frosting; the other has a thick layer. When you dive your fork into the cake with less frosting, you're going to get more cake, whereas when you use that same fork for the cake with more frosting, you're going to get less cake."

Here, the fork is the laser, the frosting is the coating and the cake is the microplastic.

What's next

The next phase of this work is to take this technique and apply it to actual pollutants within microplastics in simulated environmental situations.

"We haven't measured any real environmental samples of microplastics yet," Samantha said. "The microplastics we're currently using in the lab were purchased from a chemical supplier, so they don't have pollutants in them since they haven't been exposed to the environment.

"Next, our plan is to apply a mix of pollutants to the microplastic so we can see how they penetrate — how far they absorb or if they stay near the surface. Then we'll simulate environments to better understand microplastic pollutant exposure in the ocean versus wastewater and so on. There is a lot of variability in these different scenarios that could affect how pollutants are absorbed."

While her research currently focuses on microplastics, which are environmental pollutants, Samantha believes this work could also be applied to other areas core to Sandia's mission, specifically how materials in the stockpile age and change over time.

"This research can be applied to any polymeric material," she said. "When we have materials that age over time, like in the stockpile, it can be hard to determine the chemical reactions that might lead to failure. But having knowledge about where different reaction products are present could give us better information about where these reactions are happening. For example, if there is a reaction occurring only at the surface of a polymer or if there is a reactive species diffusing through the polymer and reacting in other locations. Ultimately, it has the potential to give us a much better understanding of what is causing many of the failures happening in the aging process."

Inside plastic

As plastics become more commonplace, Samantha believes it is increasingly important to research what that means for our health and the materials themselves.

"Plastics are pervasive and are increasingly replacing other things that used to be made from natural materials," she said. "Clothes used to be made from natural fibers like cotton or wool, and things in our homes, like tables, used to be made from wood. But now clothes are almost always made of some sort of blend that contains polymers or plastics, and the same goes for furniture.

"This isn't necessarily a bad thing, but it underscores the importance of testing so we can understand what this means for our health and also the longevity of these items."

SAMPLE — Chemist Samantha Kruse preps a sample for the Matrix-Assisted Laser Desorption Ionization analysis. **Photo by Craig Fritz**

Save the bees

Ecology team rescues, rehomes swarm

By **Magdalena Krajewski**

BUSY BEES — Sandia's ecology team was called in to capture this swarm outside of a building on the northwest side of Sandia's Albuquerque campus on June 10. **Photo by Craig Fritz**

GOT 'EM — Evan Fahy, left, and Matt Baumann empty the captured swarm into a bin for relocation after removing the swarm from the tree. **Photo by David Lienemann**

SAVING THE BEES — Matt, left, and Evan use a capture bag to remove the queen bee and her swarm. Matt said it took a few tries but they were able to successfully capture the swarm.

"Bee swarms are a natural phenomenon and happen when another hives gets too crowded prompting the queen bee to leave that hive to start a new colony. Our task here was to safely remove the swarm and relocate them so they don't pose a risk to members of our workforce," Matt said.

Photo by David Lienemann

Mileposts

Dan Urenda 35

Deanna Montoya 25

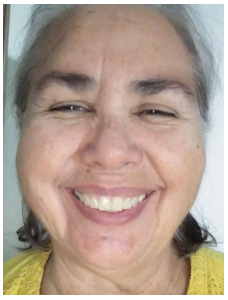
Jay Carroll 15

John Foley 15

Patrice Gregory 15

La Tonya Jenkins 15

Recent Retirees



Randy Edwards 20