SANDIA LABNEWS
PUBLISHED SINCE 1949

Vol. 74, No. 13, July 14, 2022

Sandians cycle for MS research Page 12

Radar gets a major makeover

MULTITASKERS — Principal investigator Jacques Loui, left, and a firmware developer are part of a team redesigning high-performance radar as a flexible, multipurpose sensor. **Photo by Craig Fritz**

Multifunctional, digital technology promises unprecedented flexibility, performance

By **Troy Rummler**

If radars wore pants, a lot of them would still be sporting bell-bottoms.

Significant aspects of radar haven't fundamentally changed since the 1970s, said Kurt Sorensen, a senior manager who oversees the development of high-performance radio frequency imaging technologies at Sandia. Like a record player, most military-grade systems are still analog.

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The right trousers

By **Johann Snyder**

Unless they're robot pants, we all put our pants on the same way, no matter how famous or rich or popular or anything else we may be; it's just one leg at a time. However, if they are robot pants, then it's one strap, one bolt and one battery at a time.

I'm putting on the Lockheed Martin ONYX set of "robot pants," and it's definitely a bit more involved than my regular trousers.

"The ONYX system is the most highly customizable of our test devices, so it's the system that usually takes the longest to get fitted into," says David Wood, a recently

— CONTINUED ON PAGE 5

ROBOT PANTS — Electromechanical technologist Divina Calderon observes as a test subject takes the ONYX wearable robotics for a test stroll on a treadmill. **Photo by Craig Fritz**

SANDIA LAB NEWS
PUBLISHED SINCE 1949
Managed by NTESS LLC for the National Nuclear Security Administration

Sandia National Laboratories

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Sandia National Laboratories is a multimission laboratory managed and operated by National Technology & Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.

Published on alternate Thursdays by Internal, Digital and Executive Communications, MS 1468

LAB NEWS ONLINE: sandia.gov/LabNews

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LAB NEWS Notes

Lab News may contain photos shot prior to current COVID-19 policies. Individuals in photos followed all social distancing and masking guidelines that were in place when photos were taken.

EDITOR'S NOTE: Please send your comments and suggestions for stories or for improving the paper. If you have a column (500-800 words) or an idea to submit, contact Lab News editor Katherine Beherec at kgbeher@sandia.gov.

20 years of energy internships

FUN IN THE SUN — From left to right, Sandra Begay, a Sandia engineer and member of the Navajo Nation; Sarah LaVallie, an intern in the tribal energy internship program and a member of the Turtle Mountain Band of Chippewa Indians; Rachel Herring, another year-round intern and a member of the Choctaw Nation; at the Agua Caliente Band of Cahuilla Indians' off-grid solar-powered trading post. Sandia's tribal energy internship program has provided two decades of real-world experience for Native and Alaska Native STEM students. **Photo by Lorenzo Vidali**

Tribal energy program provides training, assistance

By **Mollie Rappe**

2022 marks a major milestone for Sandia's groundbreaking **tribal energy internship program:** two decades of meeting the growing renewable energy technical needs of Native American tribes and providing valuable, real-world experience for Native and Alaska Native science, technology, engineering and math students.

"My hope for the interns is for them to be leaders in clean energy, leaders in sustainable development, leaders in renewable energy projects," said engineer Sandra

Begay, who created the program in 2002 and is a member of the Navajo Nation. "I also hope that they have a little bit easier path than what I've had. I enjoy having a relationship with the interns beyond the internship program; I want to help them in their academic endeavors and also when they choose what they want to do with their life."

Since its inception, the program has provided valuable experiences for 47 undergraduate and graduate STEM students, approximately two-thirds women, from 24 different Native American and Alaska Native tribes. The internship program is sponsored by DOE's Office of Indian Energy Policy and Programs.

Value of the tribal energy internship program

The core of the internship program is a full-time, 90-day summer experience where Sandra passes down her decades of experience working with tribes on renewable energy projects. In turn, the interns bring in the latest knowledge from their classes and their different experiences. Each student works on a research paper and final presentation that builds off their academic background and tribal membership.

In addition to the summer interns, Sandra also has interns who work for her part-time all year, while also taking classes. This year she has three summer interns and two year-round interns.

"I've always been interested in renewable energy, but this internship program has really given me a sense of purpose in what I want to do," said Sarah LaVallie, a year-round intern in the program who is pursuing a master's degree in science, technology and environmental policy from the University of Minnesota and is a member of the Turtle Mountain Band of Chippewa Indians. "Through this program I've been able to meet some of my greatest mentors, and it's been a great way to learn about tribal renewable energy projects. Getting to see some of these projects that I've been reading about for years was really cool and getting to learn some of the reasons why tribes decided to pursue renewable energy."

After their internships, approximately 20% of prior interns stayed at Sandia as year-round interns, while about 11% were eventually hired as Sandia employees. Other interns have gone on to work at the DOE Office of Indian Energy Policy and Programs; form a nonprofit to bring solar installation, maintenance and support to native communities across the country; work as an engineer for the Navajo Tribal Utility Authority overseeing projects of more than 150 megawatts of solar power; and become a professor. More broadly, about half of the interns have pursued research directly related to renewable energy in Indian Country, 36% remained in STEM fields and 4% work for or started nonprofits.

Visiting renewable energy sites

In addition to working on real-world projects and receiving significant mentorship, as part of the program Sandra takes the students to renewable energy projects on tribal lands to learn about the challenges and successes of the projects while also meeting tribal energy leaders.

"I bring the students out to projects where it's possible they do some technical assistance work," Sandra said. "Two of the projects I've chosen to highlight as successes are the Campo Kumeyaay wind farm and the Agua Caliente solar installation. I chose these two projects because they are very different in the approach, very different in the tribe and two different technologies. They've been fielded and working for at least 15 years. It's really the people at the tribal administration — the leaders, the project managers — that can tell you what actually happened to get these projects in the ground."

Todd Hooks, the director of economic development for the Agua Caliente Band of Cahuilla Indians, whose been hosting student interns for several years, agrees with the value of the site visits.

"It's one thing to read the information through journals or reports or participate in conferences; it's a whole other thing to come out, look, touch, feel and see the real context and the hurdles to overcome to make things like this happen," he said of the interns getting to visit the tribe's solar-powered trading post.

The Agua Caliente Band of Cahuilla Indians decided to power their off-grid trading post with solar panels and batteries, instead of simply replacing a failing propane generator, or marring their natural vistas and the historical home of the tribe by connecting the trading post to the electric grid.

"I think what I've learned so far from these visits is that each project is really individualized," said Rachel Herring, another year-round intern who is pursuing a master's degree in international environmental policy at the Middlebury Institute and is a member of the Choctaw Nation. "I've found that it's been really important to see it in real life, see what those challenges are and be an active listener to the tribes and understand what's going on."

The Kumeyaay wind farm consists of 25 wind turbines on land leased from the Campo Kumeyaay tribe. In addition to the land-lease revenue, the tribe also gets royalties from the power sold to San Diego Gas and Electric Co., which provides power to San Diego County and the city of San Diego. Mike Connolly Miskwish, a member of the Campo Kumeyaay tribe who was on the tribal council when the wind project was approved and installation began, said the money from the wind farm helped to sustain the tribe during the Great Recession.

He also agreed about the value of the program.

"I would have really liked this when I was young," Connolly Miskwish said of the internship program. "If I had been able to see how I could be an engineer, be a scientist, and still contribute to my community, contribute both to the economic base and to the safety and health of the people in my community. I would have liked to have had been able to see something like this when I was a young engineer."

WATCH VIDEO

This spring, two Sandia tribal energy interns visited California tribes, Campo Kumeyaay tribe and the Agua Caliente Band of Cahuilla Indians, to learn and reflect on the tribe's successes in renewable energy.

Digital radar

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Now, Sandia is giving radar a major digital makeover. Researchers are working to replace legacy analog radars commonly used by the military with a new, digital, software-defined system called Multi-Mission Radio Frequency Architecture. The overhauled design promises U.S. warfighters unprecedented flexibility and performance during intelligence, surveillance and reconnaissance operations, even against sophisticated adversaries.

Kurt said prototype designs are currently being flight-tested using testbed radar systems on a Twin Otter turboprop aircraft, and the technology could be ready to field in the next two years.

Distinguished member of the technical staff Jacques Loui is leading Sandia's technical team. He said the project, initially funded by Sandia's **Laboratory Directed Research and Development** program and now being propelled forward by the DOD, was motivated by a desire to supply operational agility that warfighters currently don't have with analog systems.

"Agility means the ability for the sensor to be chameleon-like and adapt to the needs of the mission," Jacques said. "We want to be aware of where we are, where our friends and foes are, and we want to be able to operate unimpeded in contested environments."

Like a many-colored lizard, Sandia's digital radar can be reconfigured for different functions, like communication, navigation and electronic warfare, reducing the need for additional hardware. Users will be able to download the tools they need for each mission as firmware and software onto equipment about the size of a small toolbox.

"We are replacing legacy, analog-based signal processing hardware with state-of-the-art, digitally based signal processing firmware and software," Jacques said.

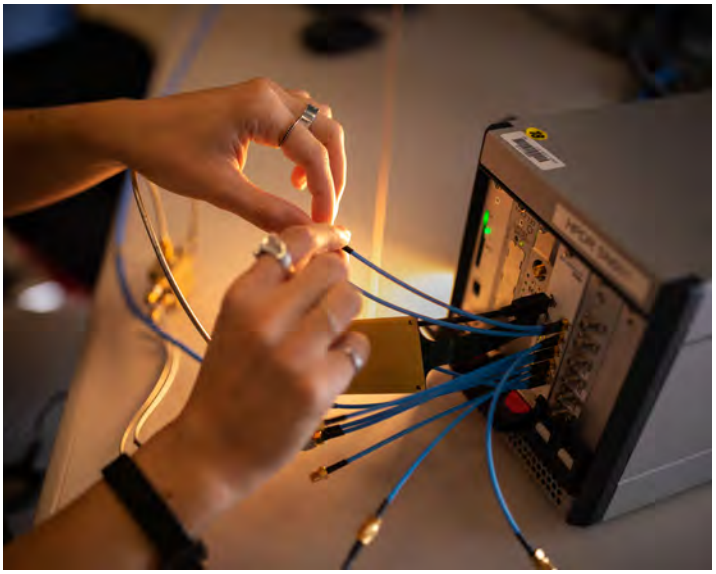
5G technology improves radar performance

"Digital, software-based radar systems do exist on small scales," Jacques said, but his team is using advanced electronic components developed for 5G cellphone systems to reap major advantages in performance and agility over similar technologies. "Our aim is to deliver outstanding sensors to our customers in the most efficient manner possible."

5G cellular technology increases the amount of information wireless technologies can transmit and receive. Sandia is using it to create digital processing tools that convert massive amounts of analog data to digital signals and vice versa, such as a digital version of **synthetic aperture radar**, a remote radio frequency imaging technology widely used for many national security missions.

Kurt said Sandia radars require extreme high performance. Now, technology is finally at a point where the lab can make the switch from analog to digital and preserve the extreme fidelity.

Advanced wireless technology also enables the new digital architecture to operate multiple radio-frequency channels simultaneously, either working together on a single function or working independently on several different functions.



HANDY WORK — A firmware developer works with a toolbox-sized prototype for a software-defined system called Multi-Mission Radio Frequency Architecture.

Photo by Craig Fritz

Performance is expected to keep on improving.

"The use of commercially available electronics is driving down the cost of these sophisticated systems, providing a clear path of upgrades as the technology continues to advance," said Steven Castillo, recently retired Sandia senior manager who worked with the project. "The new architecture also sets the stage for utilizing new, highly agile antennas of the future."

Jacques is also leading the Sandia development of these antennas.

Radar resists jamming

"The new architecture will be harder for an adversary to jam or disrupt," Jacques said.

Someone who knows they're being watched by a radar can deploy countermeasures that degrade the radar's performance, Jacques explained. But Sandia's system enables users to digitally change characteristics of their transmitted signal in real-time, making it harder to recognize. In addition, the high-performance system can be used to analyze a complex radio-frequency environment — one that has many kinds of signals, including those of an adversary.

"Signal and antenna agilities give radar operators an unprecedented amount of flexibility to alter radar operations, mitigating the effects of adversarial jamming," Jacques said.

As the new radar technology continues to mature, Sandia's foundational digital radar architecture and cross-organizational research team is positioned to enable adoption of new generations of rapidly changing technology for increased performance while at the same time tailoring the system for an expanding array of applications.

Sandia's Multi-mission Radio Frequency Architecture provides the right tools at the right time to assist with many urgent national security problems, Kurt said.

The right trousers

CONTINUED FROM PAGE 1

hired mechanical engineer who studied biomechanics while pursuing his doctorate.

And while it's true that it takes a while, almost 30 minutes in my case, once I'm done and start walking around, they're probably the coolest trousers I've ever worn. After all, none of my other pants provide motorized assistance for movement or make me sound like a cyborg when I move. So, while it's plenty cool to be wearing them, as I climb up onto the treadmill for my testing session, I can't help but wonder why, beyond just being cool, would anyone need a set of robot pants like these?

It turns out the DOE's **Office of Environmental Management** is interested in exploring whether exoskeleton systems, like the ONYX robot pants I'm wearing, can help protect workers from musculoskeletal injuries resulting from ergonomic issues, acute overexertion or even chronic overuse.

"We're looking at how these devices affect simulated workers' biomechanics, or more simply, how they move," says project lead Jason Wheeler. Thus, Sandia, along with a consortium of other labs and universities, started a wearable robotics study to determine what systems might best help protect workers when going about their regular activities.

Sandia is working with several sites, such as the Waste Isolation Pilot Plant, Savannah River Site and the Hanford Site to identify areas where workers may benefit from wearable devices that might increase efficiency and reduce fatigue in typical, yet ergonomically challenging, tasks.

"For each task, we get a baseline and a comparison of each device we're testing to determine how helpful it was or was not in performing that task," Jason says. "We can show how helpful or restrictive each device was for each task, which can inform whether or not we should consider that device for further deployment."

If you're wondering whether we'll all be wearing robot pants to work one day, Jason clarifies exactly how these devices are likely to be employed in the future. "In areas where work-related injuries are a significant factor but robots cannot replace workers, these devices will eventually become more common because they're protecting workers. How broadly they'll be applied is hard to pin down, but in perhaps 20 or 30 years, more than half of workers doing physically challenging work may be wearing a device of some sort."

EXOSKELETON WALKING — Study volunteer and story author Johann Snyder does his best Bane impression from the movie "The Dark Knight" while testing wearable robotics and a self-contained breathing apparatus on a treadmill. **Photo by Craig Fritz**

Therefore, I'm suiting up in these fancy robot pants so Sandia's wearable robotics team can investigate what systems might best enhance the safety and efficiency of DOE workers. Through a series of experiments, the team is testing various commercial systems in relevant environments to see if they'll meet the needs of the different sites where they could be potentially used. The main goals of this series of experiments are to determine what sort of short-term impact these systems may have on worker safety and productivity and to expand Sandia's ongoing exploration into robotic and automation systems for a wide variety of applications.

Naturally, these studies aren't quite as simple as just putting on my fancy robot trousers and jumping on the treadmill. According to robotics engineer Michal Rittikaidachar, "One of the biggest challenges is the dichotomy of being academically rigorous and balancing that with the needs of the site user. As a national lab and as engineers, we gravitate toward academic rigor, but we need to keep the end user in mind." A lot of that balance comes from not just mimicking tasks but understanding that in the real world with real workers, those tasks are more varied and unpredictable than in the controlled environment of a laboratory.

Beyond how these devices may improve worker efficiency and safety, another benefit of this study is how it's affecting Sandia's partnerships, especially with universities.

"We're in a unique position to test multiple devices at once; a university wouldn't necessarily be able to do that," says robotics postdoc Tamzidul Mina. "We can provide them with feedback even as they work on new technologies, and that exchange helps create a good collaboration that will reap even greater benefits in the long run."

So, while robotic trousers might be the wrong choice when it comes to fashion in general, Sandia's wearable robotics team is exploring which might be the right robotic trousers when it comes to helping the DOE workforce of the future to work safer and more efficiently.

Two Sandia researchers receive E.O. Lawrence Awards

By **Neal Singer and Troy Rummler**

Sandia pulsed-power physicist Daniel Sinars and quantum information scientist Andrew Landahl have each received a 2021 Ernest Orlando Lawrence Award, one of DOE's highest scientific midcareer honors.

Dan won in the category "National Security and Nonproliferation" and Andrew in "Computer, Information, and Knowledge Sciences."

E.O. Lawrence invented the cyclotron, for which he received the Nobel Prize in 1939, and two national labs today bear his name, said Susan Seestrom, associate laboratories director for advanced science and technology at Sandia.

"That two Sandia researchers have been acknowledged with that award in one year shows the significance of the contributions that Dan and Andrew have made to the Department of Energy in connecting science to mission — the essence of innovation," she said.

The award honors midcareer U.S. scientists and engineers for their exceptional contributions and achievements in research and development supporting the missions of DOE.

Dan, who went from proposing experiments on Sandia's Z machine to directing the facility, was cited for his "pioneering development of seminal X-ray diagnostics and their innovative application to Z-pinch implosions that transformed the experimental capabilities on the Z pulsed power facility and enabled novel, record-breaking platforms supporting our nation's nuclear security."

"Ernest Lawrence was both an excellent scientist and a great laboratory leader and is often described as the father of 'team science,'" Dan said. "I am inspired to continue striving toward the ideal that he represents.

"I'm also incredibly grateful to all the people who work in the pulsed power sciences center. We have an amazing national treasure in our unique facilities. I am constantly humbled by the effort that people put in every week to make it all work, in the expectation that what we are doing on our facilities matters. I have always viewed my primary job as making sure that it does matter, and that the science we do each week serves the national interest."

Andrew, bestowed the first Lawrence Award given in the field of quantum information science, was honored for his "groundbreaking contributions to quantum computing, including the invention of transformational quantum error correction protocols and decoding algorithms, for scientific leadership in the development of quantum computing technology and quantum programming languages, and for professional service to the quantum information science community."

Andrew said he was thrilled and honored to receive the award. "I think it's a statement not just about me, but about the growing role of the importance of quantum information science for the whole DOE complex," he said. "I think it's an acknowledgement of how important it is even for the nation, and particularly, the leadership of that coming from Sandia, especially in the area of quantum computing."

The career of Dan Sinars

Sandia's Pulsed Power Sciences Center is best known for conducting research on the world's most powerful pulsed-power machine, the 26-million ampere "Z" facility — a 120-watt household bulb uses one ampere.

Under Dan's tenure, experiments on the 104-foot-diameter machine have enabled scientists to better understand the effects of aging on the U.S. nuclear stockpile and of incoming radiation on stockpile and civilian electronics, among other information needed to keep the stockpile safe, secure and viable without the environmental costs of continued underground nuclear testing.

STAR POWER — Sandia physicist Daniel Sinars has won an Ernest Orlando Lawrence Award for helping transform the Z pulsed power facility to record a variety of record-breaking outputs supporting U.S. nuclear security, nuclear fusion energy and basic science.

Photo from Sandia archives

In a second area of scientific effort, increasingly powerful fusion experiments on the machine have blazed a trail closer to the still-to-be-reached goal of controlled high-yield nuclear fusion, with the promise of unlimited energy.

Also on Dan's watch, Z machine's huge pressures have been used to study basic science relevant to our universe, such as determining the presence of diamonds, known to be formed by carbon under high stress, on the surface of giant planets in our solar system; the behavior of black holes; alternate theories of the birth of Earth's moon; the death of suns; and the amount of water in the galaxy.

While some of this work existed before Dan's tenure, much has improved through his leadership and pioneering development of diagnostic techniques and experimental platforms.

Almost 20 years ago as a relatively new hire, Dan proposed and then used special crystals to help image what was happening in the maelstrom of energies present in Z's target area as the large machine fired. The crystals successfully blocked almost all the

radiation frequencies that had previously blinded recording devices. The remaining few frequencies could be calibrated to create high-resolution images.

Within a year, he had successfully collected his first radiograph of the early stage of an imploding wire array on Z — the signature experiment of that era.

Over the next several years, Dan made several significant improvements to this diagnostic system, which has been recognized as a major advance in the field. Enabling a wide range of science experiments, variations on the crystals remain the primary radiography diagnostic technique used on Z, and it has been adopted at the National Ignition Facility at Lawrence Livermore National Laboratory.

Other advances overseen by Dan included the implementation of several new fusion science platforms on Z. Some of these concepts for the first time combined large lasers and pulsed power in new ways to make laboratory fusion easier to achieve.

"In short," he said, "I developed and used a wide range of novel X-ray imaging and spectroscopy diagnostics to quantitatively study Z-pinch implosions, paving the way for Z to become a hotbed of science as others built upon and greatly improved my initial work."

The work of Andrew Landahl

Since joining Sandia in 2009, Andrew has helped spark the growth of the Labs' investment in quantum information science, which has led to the construction of multiple quantum computers, sensors and transceivers. As a result of Andrew's efforts, Sandia has forged a status as one of the top research institutions in the country for studying, constructing, testing and finding uses for quantum devices.

While computers are fast, quantum computers take shortcuts. They zip through certain calculations along fragile paths that conventional computers can't follow. Their ability to do so makes them one of the world's most anticipated emerging technologies — and critical for national security — because they promise to revolutionize multiple fields, including cybersecurity, energy, defense, manufacturing, finance and pharmaceuticals.

TRAILBLAZER — Sandia physicist Andrew Landahl is the first person to receive an Ernest Orlando Lawrence Award in the field of quantum information science.

Photo by Stephanie Blackwell

Among the key challenges to their development is overcoming decoherence, which is the tendency for quantum computers to revert to conventional, digital logic when disturbed by outside influences.

A distinguished scientist in Sandia's quantum computer science department and a research professor in the University of New Mexico's department of physics and astronomy, Andrew co-invented an efficient decoding protocol for quantum error correcting codes that can combat decoherence. This protocol and these codes are the basis of multibillion-dollar investments in the quantum computer industry. He is a recognizable figure on Capitol Hill, where he has briefed many congressional committees and individuals.

"The biggest surprise of quantum information science is that the laws of information are not what you think they are," Andrew said. "And given how important information is in our society, that transforms the way we think about everything, from sensing to communication to computation.

"The fact that we can do things that would seem impossible with information by exploiting information at the quantum mechanical level makes problems that were once thought to be completely

intractable simple, and we're still working out all the things you can potentially do with a quantum computer."

He and his Sandia colleagues continue to study ways to find and correct errors in quantum computers without disturbing their delicate balance.

"We have to ask the right questions. You have to have the right kind of test," Andrew said.

But Sandia's work in quantum information science goes well beyond correcting errors.

In 2011, Andrew led a landmark, $18 million project around building quantum computers, called AQUARIUS, for Adiabatic Quantum Architectures in Ultracold Systems. Both computers operated at less than a millionth of a degree above absolute zero. In addition to reaching its goals, the Sandia team invented new technologies in the process that allow engineers to build devices with atomic precision, which could have far-reaching impact across the semiconductor industry.

Andrew currently leads the software team for Sandia's **Quantum Scientific Computing Open User Testbed**, or QSCOUT, which received a 2021 R&D 100 award for providing free testbed access to researchers around the world to study and test new quantum information technologies.

"Its purpose isn't to be the most powerful quantum computer in the world, but maybe the most flexible," Andrew said.

Andrew said there's no way of knowing what the exact payoff of all this research will be in the future, but the possibilities are wide open.

"Quantum mechanics has been around for a long time, like 100 years," Andrew said. "So, what does quantum information bring to it? It brings a new way of thinking, and that way of thinking, I think, pervades my life. And that way of thinking is to say, 'Let's not try to ponder what quantum mechanics is and what it means. Let's try to understand what it is by what it does — by what you can do with it.'"

Lawrence Award recipients will receive a medal and an honorarium at a hybrid ceremony in Washington, D.C., on Sept. 22.

The most recent prior Sandia recipients of the Lawrence Award are mathematician Pavel Bochev, who received the honor in 2014, and Sandia fellow Jeff Brinker, who received it in 2002. The award was not given out in 2017-2020.

Andrew and Dan were not Sandia's only connections to this year's E.O. Lawrence awards. Professor Rachel Segalman at the University of California, Santa Barbara won in the category "Condensed Matter and Materials Science." She was a high school and college research intern from 1992 to 1997 at Sandia's Advanced Materials Lab.

Mathematician uses DOE Early Career Research Award to capture more real-world data

By **Neal Singer**

Sandia researcher Pete Bosler aims to improve the fidelity by which complex computer simulations can be guided by very fine examinations of real-world data.

His proposal's information-packed title, "High performance adaptive multiscale simulation with data-driven scale-selective subgrid parameterizations," refers to multiscale simulations that, integrated, could include individual raindrops, supercell thunderstorms and the entire global atmosphere, guided by data currently thought too fine to be used, that is, too small to be seen on a data grid, or in other words, currently subgrid.

The proposal earned Pete a 2022 DOE Early Career Research Award.

"Peter's research plan lays out a highly innovative approach to achieving more accuracy from our simulations of complex domains like climate and plasmas," Sandia manager Andy Salinger said. "As our computing resources for these mission application areas increase, there is a shift in the boundary between those phenomena we can resolve with our highest fidelity models. Those too fine-scaled need to be represented with heuristic models derived from experience. Peter will develop new algorithms that will intelligently choose which heuristic models are most appropriate to capture the unresolved processes."

When Pete graduated from the U.S. Naval Academy in 2002 with a bachelor's degree in oceanography, he served as a combat line officer in anti-submarine warfare at sea and as an anti-terrorism officer protecting ships during port visits. Then he worked shore duty as a meteorology and oceanography staff corps officer for two years.

MATH MASTER — Sandia applied mathematician Pete Bosler moves fluidly with help from very fine data sets. **Photo by Craig Fritz**

He loved the sea, and the work was patriotic, but what fascinated him throughout his service was the Navy's widespread use of computational models. "I was looking at end-product use, of course," he

said. "We would tune the sensors on our ship to the environment predicted by our computational ocean models, for example, and for our weather forecast we relied heavily on atmospheric models."

He found the models "fantastic, but not perfect." Even over the considerable evolution of the last several decades, "nature can still throw surprises at you where the models do not work well. Usually, these situations are outliers, rare occurrences, but they may be extreme events where you'd need the models most," Pete said. "I wanted to learn more about the methods behind these models and improve their performance, so I chose to study applied and interdisciplinary mathematics (at the University of Michigan) when I left the Navy."

His work, which to date has led to nine published papers, 12 invited presentations and many student interactions, has a common technique that uses equations that represent fluid flow by moving with the fluid as it evolves, rather than maintaining a fixed observation point. "Consider a drifting buoy or free-floating balloon that sample the portion of the ocean or atmosphere as they move along with it," he said.

In this complex flow, the computational elements, or particles, develop features both larger and smaller than their original configuration as they adapt to the flow taking them closer together or further apart. This can leave a simulation region relatively devoid of particles and others with too many. "The accuracy of the simulation will rapidly degrade when this occurs," said Pete. "So, we use a technique called adaptivity to fill in sparse regions of the flow with particles and remove them from regions where they may accumulate."

To do this without sacrificing accuracy, Pete proposes to conjoin these purely mathematical efforts with data sets developed from real-world observation. These help mathematical efforts remain on target, until the data cudgel goes subgrid, too small to see, or technically, finer than can be resolved.

Pete intends to circumvent this limit by linking adaptive algorithms to a data analysis technique called dynamic mode decomposition to remap data more finely.

The adaptive algorithms use partial differential equations that link to physical laws, which is attractive but expensive to use for many calculations.

"PDEs are based on physical laws, so they're attractive because they are solidly rooted in theory, but computing their solution can be very expensive," Pete said. "Data-driven methods like dynamic mode decomposition don't necessarily need a connection to physics, but with new graphics processing unit computing and machine learning infrastructure, they can be very fast and inexpensive.

"Lots of people are trying to figure out how to blend the strengths of these two ideas, using physics to inform machine learning algorithms," Pete said. "It's hard. Maybe this connection between adaptive criteria and the dynamic mode decomposition algorithm will open new pathways."

DOE Early Career Research Awards

The DOE Office of Science has selected four Sandia researchers to receive Early Career Research Awards this year. Krupa Ramasesha, Pete Bosler, Tim Proctor and Andrew Mounce will receive up to $500,000 per year for five years to advance their research. This summer, Lab News will profile each researcher.

The program, now in its 13th year, is designed to provide support to researchers during their early career years, when many scientists do their formative work. This year, the DOE awarded 83 scientists nationwide, including 27 from national laboratories.

Mileposts

Daryl McCollister 40

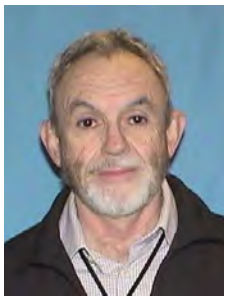
Jimmy Brown 35

Jerry Friesen 35

Elizabeth Wichman 25

Brett Chavez 20

Louis Griego 20



Ed Wyckoff 20

Rick Naething 15

PV panels catch the sun despite the snow

Alaska trials of icephobic coating show 85% increase in energy output

By **Kelly Sullivan**

A Sandia-led research team has developed a transparent, polymeric-based coating that helps photovoltaic panels continuously shed snow and ice.

Early field trials in Alaska demonstrated that coated panels can produce 85% more energy, compared to uncoated panels. Preliminary data also show that the coating maintains its ice- and snow-shedding performance for multiple months.

The DOE Solar Energy Technologies Office funded the work, and longer-term studies are planned.

"The development of icephobic coatings, which can be applied to photovoltaic modules without compromising light transmissivity, has game-changing potential for photovoltaic power plant efficiency in cold climates," said Laurie Burnham, Sandia principal investigator for a larger project on photovoltaic optimization at northern latitudes. "Sandia is very proud of this coatings work, which was largely done at the University of Michigan and led by Sandia, with additional technical support provided by the University of Alaska, Fairbanks."

The novelty of the coating lies in its dual properties of low-interfacial toughness and strength, which enable accelerated ice and snow shedding from large surfaces. While this coating has multiple applications besides solar panels, the technology's impact on the solar industry is potentially huge. Solar panels that are covered by a thick layer of snow do not generate power, amounting to significant energy losses in winter — 1% to 12% annually for a northern photovoltaic site, with monthly losses as high as 100%. The rapid build-out of photovoltaics across the northern half of the U.S. magnifies the problem: as photovoltaic expands across regions of the U.S. that regularly see snow in winter, the risk of generation outages from those photovoltaic power plants increases.

Laurie said that snow-phobic coatings, such as the one developed by this team, could be an effective strategy to mitigate those losses and increase the resilience of photovoltaic installations across the more than 30% of the contiguous U.S. that sees significant snow in winter.

According to Anish Tuteja, a materials science and engineering professor at the University of Michigan, who led the coatings research, "Icephobic coatings work well for shedding ice, but the extremely diverse physical characteristics of snow make the design of a single, broad-spectrum de-icing, snow-phobic surface difficult. For this project, we developed the first optically transparent surfaces that possess both extreme low-interfacial strength and low-interfacial toughness."

Next on the horizon is the continuation of long-term durability studies at multiple northern sites combined with economic analyses that include the amount of energy gained because of the rapid shedding of heavy snow from photovoltaic arrays.

SLICK SURFACE — A novel approach to shedding snow from photovoltaic panels, using a transparent polymeric-based icephobic coating developed by Sandia, the University of Michigan and the University of Alaska, Fairbanks, is demonstrated at a field site in Alaska. In these photos, the coating was applied to the panels that are not covered in snow.

Photos by Christopher Pike, University of Alaska, Fairbanks

Sandia student intern inspires women in STEM at summer physics camp

By **Debra Menke**

The sixth annual Summer Physics Camp for Young Women, cosponsored by Sandia, Los Alamos National Laboratory and the Hawaii Science and Technology Museum virtually hosted 40 teens from New Mexico and Hawaii this summer.

The camp gave teenage girls in grades eight through 12 the chance to explore careers in science, technology, engineering and math. Sandia student intern Alex Miera, an undergraduate studying electrical and computer engineering at Worcester Polytechnic Institute, led portions of the camp.

Alex led the teens in creating, calibrating and using sensors to control a robotic hand.

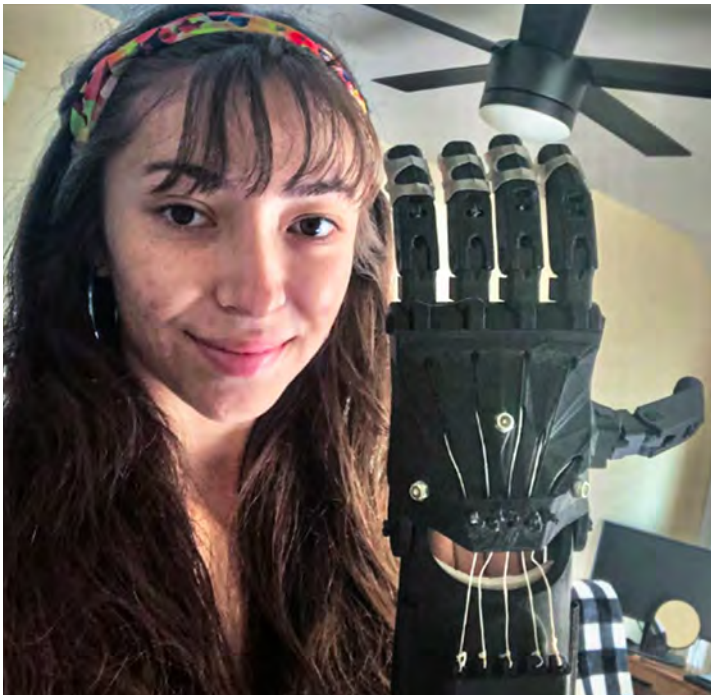
Participants joined the camp from throughout New Mexico and represented 31 schools in the state. Five of the students live in Hawaii. The camp brings STEM to a diverse group of underrepresented students; 82% of participants belong to minority groups and about 45% of this year's participants reported that they qualify for free school lunch.

As a student intern, Alex was able to talk with students about her journey from a kid with an interest in science to a college student working at a national laboratory.

Alex began learning about robotics and electrical and computer engineering early on after her younger brother, who was born with a neurological condition called Chiari Malformation Type 1, prevented him from walking correctly. She wanted to understand the mechanics of how orthotics and prosthetic devices could help her brother and others in need.

After attending countless appointments and shadowing her brother's orthotist, Alex completed a middle school science project on orthotics and prosthetics. As a result, she built her first prosthetic hand with the assistance of her school's 3D printing club, and e-NABLE, an online global community of digital humanitarian volunteers using 3D printers to make free and low-cost prosthetic limb devices for children and adults.

Her desire to build prosthetics remained strong through high school and Alex continued to feed her curiosity through job shadowing, researching and attending science and robotics camps.



BIONIC DEMO — Student intern Alex Miera models a robotic hand that she demonstrated during the Summer Physics Camp for Young Women. The event was held virtually and cosponsored by Sandia, Los Alamos National Laboratory and the Hawaii Science and Technology Museum.

Photo by Alex Miera

"Through a local robotics camp hosted by Shelly Gruenig, and her company BeGreaterThanAverage, and the Robotics Vehicle Range out at Sandia and a lot of luck, I was able to get an internship with Advanced Field Ops and Robotics at Sandia National Labs my freshman year of college," Alex said.

Soon after she joined Sandia, she began working on a project related to exoskeletons. Under the guidance of mechanical engineer Jason Wheeler and the robotics team, the DOE Environmental Management Wearable Robotics Program has grown into a multipartner program.

During her year-round internship, Alex would like to learn how exoskeletons, prosthetics, orthotics, neuroscience, anatomy and physiology relate to electrical and computer engineering.

"Through the physics camp project I supported, robotics camp training, and growing body of knowledge Sandia has provided me, I realized that sensors were that glue," Alex said. "Our bodies and robots need sensors to respond to their environments."

After she graduates, Alex wants to follow her dreams of work in rehabilitation, medical monitoring and educating others.

"I would like to pursue graduate school and maybe even a doctorate focused on or around sensors, specifically sensors that will support vital sign monitoring or rehabilitation efforts," she said. "Later on, I would love to spend part or all of my time teaching. I also want to follow in the footsteps of my parents and Sandia mentors who taught me to persevere, never give up and follow my dreams."

Bike team raises $300K for MS research

Sandia cyclists find support, fun in yearly ride

LEADING THE WAY — Sandia engineer Andy Scholand leads his teammates out of a tunnel underneath Paseo del Norte in Albuquerque during a 55-mile training ride on Saturday, July 9. Sandia cybersecurity researcher David Scrymgeour formed the Penultimates cycling team in 2010.

Photo by Craig Fritz

By **Manette Fisher**

Since 2010, some dedicated Sandia cyclists have been rising before the sun on summer weekends to meet and train for an annual ride that supports multiple sclerosis research.

Last Saturday, team members who participated in their weekly training ride completed nearly 60 miles. By the end of the summer, many of them will complete the century ride distance — 100 miles in one day — followed by another day of riding 50 miles for the Bike MS ride weekend in Albuquerque.

The team, The Penultimates, has nearly 30 riders. Participants in the Bike MS ride must fundraise a minimum of $250 for the MS Society. Many of the team's riders pay that as a donation while others raise more than $3,000 every year, said cybersecurity researcher and Penultimates team leader David Scrymgeour. On average, the team raises $30,000 per year for MS research.

"We've now raised an accumulative total of more than $300,000 over the years and that's something we're pretty proud of," David said.

David, who learned he has MS in 2007 as a Sandia Truman Fellow, said it's an often-invisible, lonely disease. It's a chronic, unpredictable illness that impacts the brain and spinal cord, which make up the central nervous system. Symptoms of MS can include numbness, tingling, mood changes, memory problems, pain, fatigue, blindness and paralysis, according to the MS Society website. There is no cure for MS, but treatment options can reduce its severity. The website says everyone's experience with MS is different, and symptoms may be temporary or long lasting.

"It's one of these things where, you may not be aware, but you probably know someone with MS," David said.

Two years after his diagnosis, David and his wife planned to ride Bike MS together, but his wife got pregnant, and he completed the ride alone while she volunteered at a rest stop.

"Participating in the ride was the first time that I had really acknowledged to anybody else that I had MS. Most of the volunteers and riders have some connection to MS and there were even a few riders who had MS and I wouldn't have known," David said. "At the time, I thought, 'Maybe life is not over.' I've done the ride every year since."

David formed the Penultimates team the next year and many of riders came from the Labs. He said the team has always been composed of more than 50% Sandia employees; the rest of the members are their families and friends. David said the ride is about doing something together for a cause that is personal to many members. The team also supports a rest stop on the second

day of the event that is primarily manned by Penultimates' spouses and children.

"I'm going to do this as long as I'm physically able," David said. "There are a lot of other people who ride in the event who say the same thing. Some have a pretty severe disability at this point and ride on hand cycles or trikes. It's so welcoming and that's why people keep returning."

Sandia competitive intelligence specialist Kelli Howie began riding with the team a few weeks after she was hired at Sandia in 2019 and said the group has become like family.

"They are the people I call when I have an actual emergency and need a close friend to help," she said. "It's interesting because I end up working with so many people on this team on other causes at Sandia, whether it's part of the Sandia Women's Action Network committee or the peer mentoring network. I always say if you're working on a heartwarming cause at Sandia, you may also be a Penultimate."

Sandia employees who want to ride in Bike MS do not have to be part of the Penultimate team. They can also ride alone, form their own teams or join any number of local riding groups who participate. However, for those looking for a group that won't leave anyone behind during training rides, David said the Penultimates is a great option.

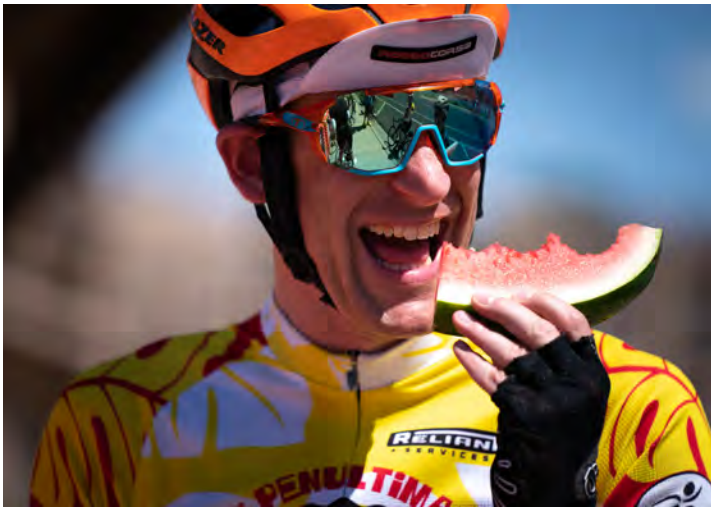
"If you can ride a bike, great. We want to share that love of biking with you," he said. "Maybe you're not training up to 100 miles. Maybe you're working up to 8 — that's OK."

CYCLING FOR A CAUSE — Molly Arevalo, Steve Othling and Sandia cybersecurity researcher David Scrymgeour, left to right, ride north on Tramway Boulevard with the Penultimates cycling team during a 55-mile training ride on Saturday. Since 2010, the group has raised more than $300,000 to support multiple sclerosis research. **Photo by Craig Fritz**

This year's Bike MS takes place Aug. 27-28 in Albuquerque. Routes range between 8 and 100 miles. In addition to the $250 fundraising commitment, there is an additional ride participation fee, which is currently $60 but increases monthly as the event approaches.

The MS Society is always looking for new riders and volunteers to help rebuild and grow the ride that was negatively affected by the pandemic, David said.

Anyone who would like to join the Penultimates or volunteer for the ride can contact David for more information. Saturday rides are listed on the team blog and include maps for each week's ride.



FUELING UP — Eric Beidermann takes a snack break long into a 55-mile training ride with the Penultimates on Saturday. **Photo by Craig Fritz**

BENEVOLENT BIKERS — Materials scientist Laura Biedermann, who is used to riding a lightweight bike, lifts a teammate's heavier bike after a 55-mile training ride on Saturday. On average, the group raises $30,000 per year for multiple sclerosis research. **Photo by Craig Fritz**


The threat is real.
Our moment is now.
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Sandia National Laboratories
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SUBMIT
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James Peery's "Our Rally Cry" presentation
staff questions on the Rally Cry Website
the Q&A on July 18th from 2-3 p.m. (MT)