



Sandia microneedles technique may mean quicker diagnoses of major illnesses

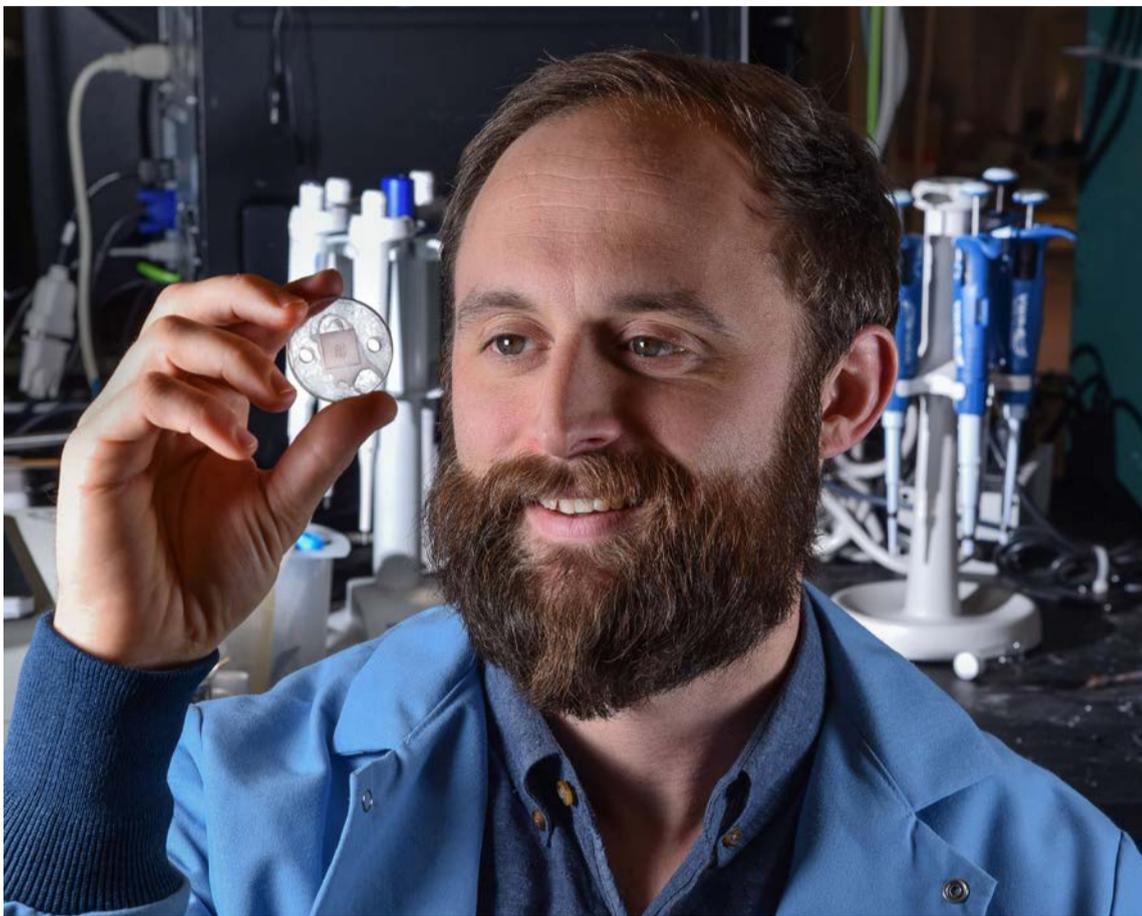
Exposure to chemical and biological attacks determined more rapidly

By **Neal Singer**

When people are in the early stages of an undiagnosed disease, immediate tests that lead to treatment are the best first steps. But a blood draw — usually performed by a medical professional armed with an uncomfortably large needle — might not be quickest, least painful or most effective method, according to new research.

Now a technique using microneedles able to draw relatively large amounts of interstitial fluid — a liquid that lurks just under the skin — opens new possibilities. Previously, microneedles — tiny, hollow, stainless steel needles — have drained tiny amounts of interstitial fluid needed to analyze electrolyte levels but could not draw enough fluid to make more complicated medical tests practical. The new method's larger draws could be more effective in rapidly measuring exposure to chemical and biological warfare agents as well as diagnosing cancer and other diseases, says Sandia researcher and team lead Ronen Polsky, who is principal investigator on the project sponsored by

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HIGH VOLUME NEEDLING — Philip Miller examines a microneedle device. The new device design uses an array of needles and can extract 20 microliters of interstitial fluid, compared to the two microliters that the previous version of the device achieved.

Photo by Randy Montoya

Quantum computing steps further ahead with new Labs projects

By **Neal Singer**

Quantum computing is a term that periodically flashes across the media sky like heat lightning in the desert: brilliant, attention-getting and then vanishing from the public's mind with no apparent aftereffects.

Yet a multimillion dollar international effort to build quantum computers is hardly going away.

And now, three new projects led by Sandia (and a fourth a year underway) aim to bring the wiggly subject into steady illumination by creating:

- A quantum computing “testbed” with accessible components on which industrial, academic and government researchers can run their own algorithms.
- A suite of test programs to measure the performance of quantum hardware.
- Classical software to ensure reliable operation of quantum computing testbeds and coax the most computational utility from them.
- High-level quantum algorithms that explore connections with theoretical physics, classical optimization and machine learning.

These three- to five-year projects are funded at \$42 million by the Department of Energy's Office of Science and are part of Sandia's Advanced Science and Technology portfolio.

Quantum information science “represents the next frontier in the information age,” said U.S. Secretary of Energy Rick Perry this fall when he announced \$218 million in DOE funding for the



TRAPPED FOR THE FUTURE — Sandia researchers, including Peter Maunz (left) and Ojas Parekh, are looking to shape the future of computing through a series of quantum information science projects. As part of the work, they will collaborate to design and develop a new quantum computer that will use trapped atomic ion technology. Photo by Randy Montoya

research. “At a time of fierce international competition, these investments will ensure sustained American leadership in a field likely to shape the long-term future of information processing and yield multiple new technologies that benefit our economy and society.”

Partners on three of the four Sandia-led projects include the California Institute of Technology, Los Alamos National Laboratory, Dartmouth College, Duke University, the University of Maryland and Tufts University.

Birth of a generally available quantum computer

Design and construction of the quantum computer itself — formally known as the Quantum Scientific Computing Open User Testbed (QSCOUT) — under the direction of Sandia researcher Peter Maunz, is a \$25.1 million, five-year project that will use trapped atomic ion technology.

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My bedtime story

Sandia's MD recounts his struggle to find the Land of Nod



Dr. Dan Azar, the California site's in-house physician.

Photo courtesy Dan Azar

By **Dr. Dan Azar**

I am writing this story about sleep at 3:33 a.m. on a Tuesday. It is both a personal story, and a shared one. Almost everyone at some point in their life struggles with going to sleep, staying asleep or getting enough sleep. I certainly have.

As a young man, I tolerated inadequate and irregular sleep much better than I can today. Youthful vitality and enthusiasm partly compensated for the lack of sleep. But today, my relationship with sleep is much more challenging. Although I'm usually so exhausted at bedtime I fall asleep without difficulty, I wake up about two or three times each night. I start worrying about deadlines, which prevents me from being able to go back to sleep — a situation made worse because then I worry about how my lack of sleep is going to ruin the next day.

So how do I deal with this?

For me, it starts with acknowledging some truths: I need about seven hours of sleep each night to feel rested the following day. Nothing more profoundly affects how I feel today than how I slept last night. Without sufficient or

restful sleep, I am irritable and plagued with negative thoughts.

What works for me?

Through trial and error, using techniques that work for others, I found a set of strategies that works for me:

1. On work days I set my alarm to wake up at the same time every day, and I never hit snooze. It just delays the inevitable. It's either time to get out of bed, or it's not.
2. On weekends I give myself a chance to catch up on any sleep deficit, but my eyes often open anyway within an hour of my usual wake-up time.
3. I exercise every day. Exercising results in deeper sleep. And of course, it also positively affects my cardiovascular health, weight management and stress relief.
4. I try to start making my way to the bedroom at the same time every night. Accepting that the day is over is the most challenging step for me, so I enlisted my wife to gently remind me how late it is getting.
5. I have a pre-sleep washing, flossing and brushing routine. Because it is repetitive and requires little thought, it is relaxing.
6. Once I get in bed, I read. Reading helps me

calm down. I don't use electronic devices at bedtime. No television, no computer, no smart phone. The brain-stimulating artificial light source isn't the only problem with electronic devices; reading emails, online shopping and reading social media also keeps your mind spinning.

7. When I wake up in the middle of the night, I use a simple meditation focusing on my breathing to relax me. If recurring thoughts or worries persist, I take a few minutes to write those down, acknowledge what I can and can't do tomorrow about that concern and do my best to let it go. I can't do much about any of it at 1 a.m.
8. If I spontaneously wake up in the morning an hour or less before my alarm setting I try meditating for five minutes. If I can't get back to sleep because of my too-busy brain, I get up and start my day early. For me, it is better to be productive than to start my day frustrated at not being able to get a few more minutes of sleep. I do something positive like exercising or the paperwork I dreaded doing yesterday.
9. Most of the time these strategies work for me — not every night, but most nights.

Takeaway messages:

Be realistic. Your body and brain typically need between seven and eight hours sleep to recover and function well the following day. Block out that time and stick to your schedule.

Be consistent. Find a pattern that works for you and do your best to stick with it.

Sleep medications are not a long-term solution. If used regularly you will become physically and psychologically dependent on ever-increasing doses. Also, alcohol is a terrible sleep remedy — it actually interferes with restful sleep.

Learn to meditate. It will help you relax enough to sleep, as well as de-stress, improve mental clarity and function better during the day. Sandia offers a wide variety of meditation programs, including mindfulness training, weekly guided meditation sessions and individual practice.

Contact Joy MacPherson with questions.

You don't have to do this alone. Employee Health Services offers many resources to help you deal with health problems — including depression and anxiety — that interfere with restful sleep.

Start by enrolling in the Improve Sleep Health Action Plan and work one-on-one with a health coach to create an individualized plan to help you sleep better. 



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LAB NEWS ONLINE: sandia.gov/news/labnews



MEETING OF THE MINDS — Sandia's last five directors came together recently for discussions on the Labs' future direction. Pictured are (left to right) Paul Hommert, July 2010-July 2015; Jill Hruby, July 2015-April 2017; Director and Labs President Stephen Younger; Tom Hunter, April 2005-July 2010; and C. Paul Robinson, August 1995-April 2005.

Photo by Randy Montoya

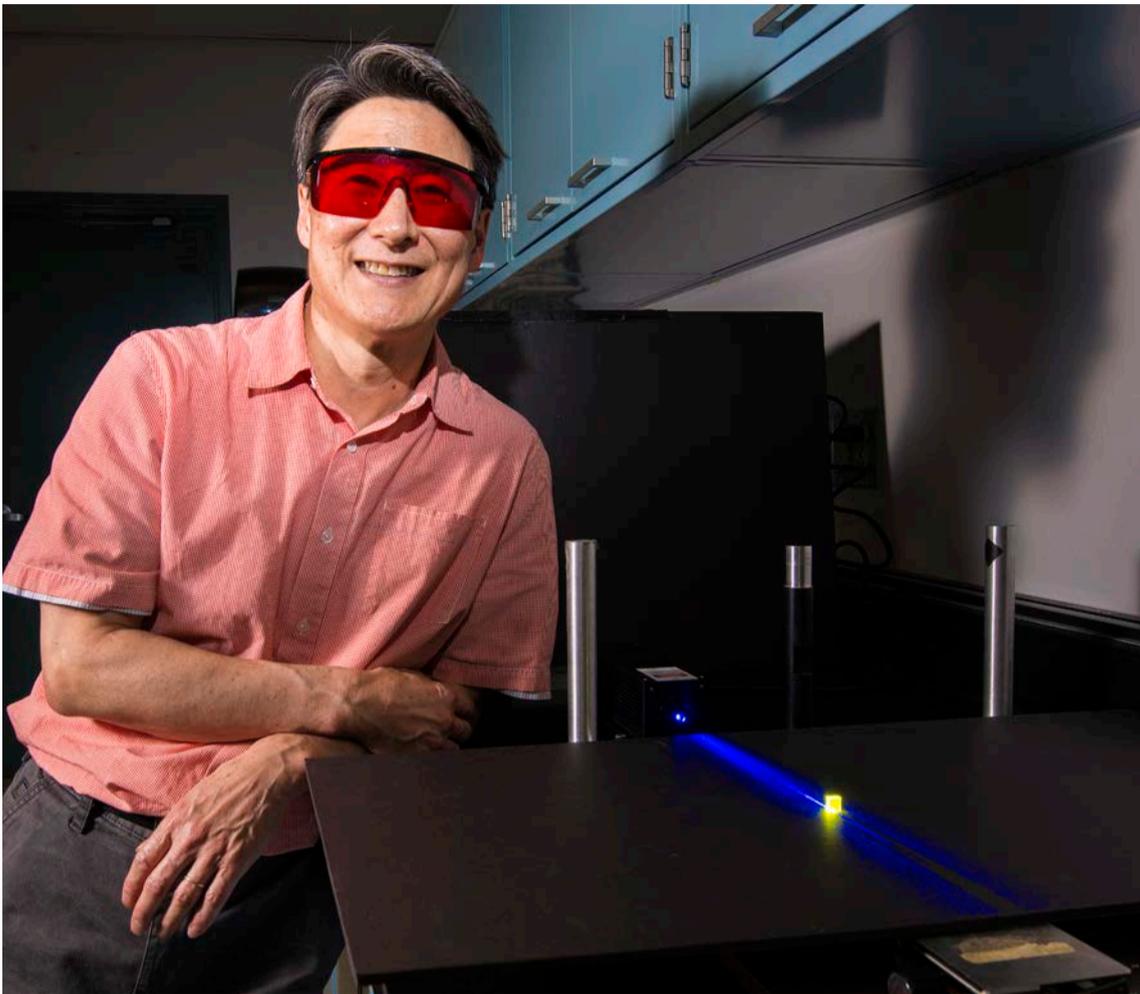
LABNEWS Notes

EDITOR'S NOTE: Lab News seeks guest columnists with observations on life at the Labs or on science and technology in the news and in contemporary life. If you have a column (500-750 words) or an idea to submit, please contact Jim Danneskiold, the acting editor.

The benefits of engineered light

Engineered light could improve health and food, Nature paper suggests

By **Neal Singer**



TAKING THE LID OFF LED LIGHT — In a recent paper, Jeff Tsao and his co-authors say that controlled lighting at LED wavelengths and intensities has nearly unlimited potential for social and scientific advances. **Photo by Randy Montoya**

People who believe light-emitting diodes, or LEDs, are just an efficient upgrade to the Edison lightbulb are stuck in their thinking, suggest Sandia researcher Jeff Tsao and colleagues in a Nature Perspectives article published in late November.

“LED lighting is only in its infancy,” the authors write. “We now stand at the threshold of what might be called engineered light.”

Light intentionally controlled in time, space and spectral content can reward not just human optics with better lighting but also can help regulate human health and productivity by eliciting various hormonal responses.

Moreover, in the plant kingdom, the authors say, tailored LED wavelengths and intensities can efficiently stimulate plant growth, alter their shapes and increase their nutritional value, opening a new world of scientific and technological possibilities for indoor farming.

“That’s not to ignore the integration of LEDs with the internet of things,” Jeff says, “which is already happening with LED integration with electronics, sensors and communications.”

The inevitable broadening of LED usage could add value to society far greater than the energy saved in lighting homes and buildings, the authors say.

The research was supported by the Department of Energy’s Solid State Lighting Program.

Sandia
CaliforniaNews

Sandia/California hosts DOE deputy secretary

By **Michael Padilla**

Deputy Secretary of the U.S. Department of Energy Dan Brouillette visited Sandia/California on Dec. 4. It was Brouillette’s first visit to the site.

The purpose of his visit was to become familiar with Sandia/California’s contributions to national security through nuclear deterrence and other missions.

The visit was hosted by Associate Labs Director Dori Ellis, who welcomed Brouillette and led him on tours and briefings throughout the afternoon.

Brouillette met with early career professionals, including Melissa Weigand, Krupa Ramasesha, Rachael Gutierrez, Manuel Lopez Martinez, Kali O’Neil, Anthony Trimble, Joey Carlson and Melinda Sweany, Anthony Juarez and Ariella Walker.

During Brouillette’s visit, Center 8200 Director Mike Hardwick provided an update on the W80-4 and California weapon systems, and Tim Shepodd gave a briefing about Sandia’s weapons cell.

Center Director Heidi Ammerlahn and Karim Mahrous then presented information about civilian cyber and the grid, followed by Center director Anup Singh and Jim Carney, who gave an update on genomic security. Afterwards, Davina Kwon and Craig Tewell briefed Brouillette in the Lightweight Structures Lab.

At the Combustion Research Facility (CRF), Center director Bob Hwang provided Brouillette with an overview of the CRF. Afterwards, Mark Musculus and Amanda Dodd discussed various research projects conducted at the CRF, including heavy-duty diesel and gaseous fuels optical engines and science-based innovations.



CRF WORK — Sandia researcher Amanda Dodd explains research conducted at Sandia’s Combustion Research Facility.

Photo by Dino Vournas



EARLY CAREER DISCUSSION — DOE Deputy Secretary Dan Brouillette (left) met with early career professionals during his visit to Sandia/California.

Photo by Dino Vournas



DEP SEC VISIT — DOE Deputy Secretary Dan Brouillette (center) recently visited Sandia/California. Pictured from left: Captain James Colgary, chief of staff, Office of the Deputy Secretary of Energy; Division 8000 Associate Labs Director Dori Ellis; Brouillette; Jeffrey Harrell, manager of NNSA’s Sandia Field Office; and Steve Black, director of DOE’s Office of Intelligence and Counterintelligence.

Photo by Dino Vournas

Quantum computing

CONTINUED FROM PAGE 1

Trapped ions are uniquely suited to realize a quantum computer because quantum bits (qubits) — the quantum generalization of classical bits — are encoded in the electronic states of individual trapped atomic ions, Peter said.

“Because trapped ions are identical and suspended by electric fields in a vacuum, they feature identical, nearly perfect qubits that are well isolated from the noise of the environment and therefore can store and process information faithfully,” he said. “While current small-scale quantum computers without quantum error correction are still noisy devices, quantum gates with the lowest noise have been realized with trapped-ion technology.”

A quantum gate is a fundamental building block of a quantum circuit operating on a small number of qubits.

Furthermore, in trapped-ion systems, Peter said, “It is possible to realize quantum gates between all pairs of ions in the same trap, a feature which can crucially reduce the number of gates needed to realize a quantum computation.”

QSCOUT is intended to make a trapped-ion quantum computer accessible to the DOE scientific community. As an open platform, Peter said, it will not only provide full information about all its quantum and classical processes, it will also enable researchers to investigate, alter and optimize the internals of the testbed, or even to propose more advanced implementations of the quantum operations.

Because today’s quantum computers only have access to a limited number of qubits and their operation is still subject to errors, these devices cannot yet solve scientific problems beyond the reach of classical computers. Nevertheless, access to prototype quantum processors like QSCOUT should allow researchers to optimize existing quantum algorithms, invent new ones and assess the power of quantum computing to solve complex scientific problems, Peter said.

Proof of the pudding

But how do scientists ensure that the technical components of a quantum testbed are performing as expected?

A Sandia team led by quantum researcher Robin Blume-Kohout is developing a toolbox of methods to measure the performance of quantum computers in real-world situations.

“Our goal is to devise methods and software that assess the accuracy of quantum computers,” Robin said.

The \$3.7 million, five-year Quantum Performance Assessment project plans to develop a broad array of tiny quantum software programs. These range from simple routines like “flip this qubit and then stop,” to testbed-sized instances of real quantum algorithms for chemistry or machine learning that can be run on almost any quantum processor.

These programs aren’t written in a high-level

computer language, but instead are sequences of elementary instructions intended to run directly on the qubits and produce a known result.

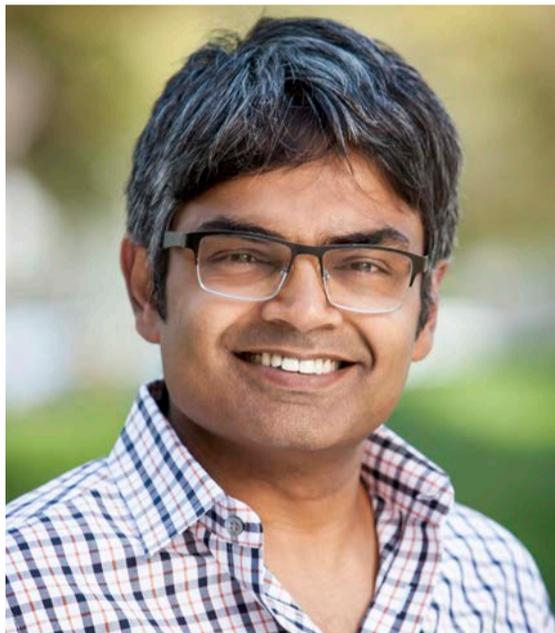
However, Robin says, “because we recognize that quantum mechanics is also intrinsically somewhat random, some of these test programs are intended to produce 50/50 random results. That means we need to run test programs thousands of times to confirm that the result really is 50/50 rather than, say, 70/30, to check a quantum computer’s math.”

The team’s goal is to use testbed results to debug processors like QSCOUT by finding problems so engineers can fix them. This demands considerable expertise in both physics and statistics, but Robin is optimistic.

“This project builds on what Sandia has been doing for five years,” he said. “We’ve tackled similar problems in other situations for the U.S. government.”

For example, he said, the Intelligence Advanced Research Projects Activity reached out to Sandia to evaluate the results of the performers on its LogiQ program, which aims to improve the fidelity of quantum computing.

“We expect to be able to say with a certain measure of reliability, ‘Here are the building blocks you need to achieve a goal,’” Robin said.



THINKING PROCESS FOR A PROCESSOR — Mohan Sarovar is working to develop a software for quantum testbeds. Sandia’s quantum computer will play a role analogous to those of graphics processing units in today’s high-performance computers. **Photo by Randy Wong**

Quantum and classical computing meet up

Once the computer is built by Peter’s group and its reliability ascertained by Robin’s team, how will it be used for computational tasks?

The Sandia-led, \$7.8 million, four-year Optimization, Verification and Engineered Reliability of Quantum Computers project aims to answer this question. Los Alamos and Dartmouth College are partners.

Project lead and physicist Mohan Sarovar expects that the first quantum computer developed

at Sandia will be a very specialized processor, playing a role analogous to that played by graphics processing units in high-performance computing.

“Similarly, the quantum testbed will be good at doing some specialized things. It’ll also be ‘noisy.’ It won’t be perfect,” Mohan said. “My project will ask: What can you use such specialized units for? What concrete tasks can they perform, and how can we use them jointly with specialized algorithms connecting classical and quantum computers?”

The team intends to develop classical “middleware” aimed at making computational use of the QSCOUT testbed and similar near-term quantum computers.

“While we have excellent ideas for how to use fully developed, fault-tolerant quantum computers, we’re not really sure what computational use the limited devices we expect to see created in the near future will be,” Mohan said. “We think they will play the role of a very specialized co-processor within a larger, classical computational framework.” The project aims to develop tools, heuristics and software to extract reliable, useful answers from these near-term quantum co-processors.

At the peak

At the most theoretical level, the year-old, Sandia-led Quantum Optimization and Learning and Simulation project’s team of theoretical physicists and computer scientists, headed by researcher Ojas Parekh, have produced a new quantum algorithm for solving linear systems of equations — one of the most fundamental and ubiquitous challenges facing science and engineering.

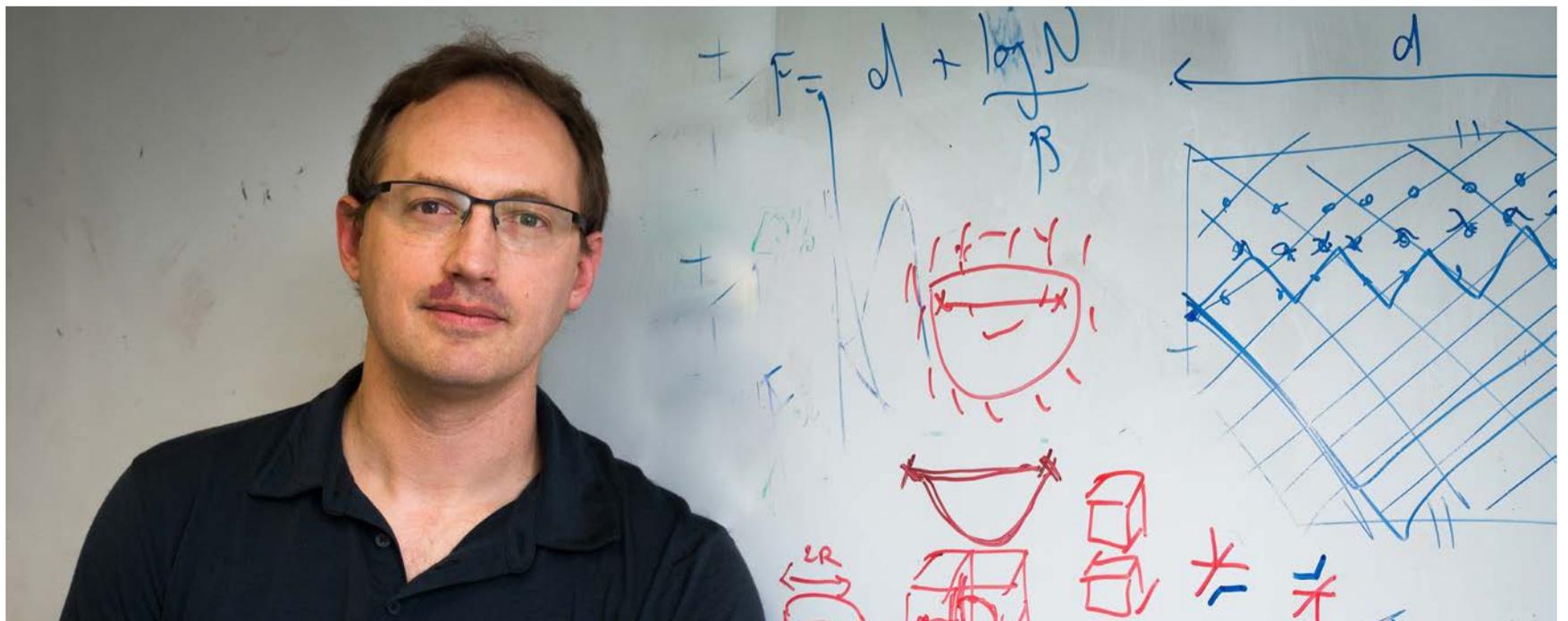
The three-year, \$4.5 million project, in addition to Sandia, includes Los Alamos, the University of Maryland and Caltech.

“Our quantum linear systems algorithm, created at LANL, has the potential to provide an exponential speedup over classical algorithms in certain settings,” Ojas said. “Although similar quantum algorithms were already known for solving linear systems, ours is much simpler.”

“For many problems in quantum physics, we want to know, what is the lowest energy state? Understanding such states can, for example, help us better understand how materials work. Classical discrete optimization techniques developed over the last 40 years can be used to approximate such states. We believe quantum physics will help us obtain better or faster approximations.”

The team is working on other quantum algorithms that may offer an exponential speedup over the best-known classical algorithms. For example, Ojas said, “If a classical algorithm required 2,100 steps — two times itself one hundred times, or 1,267,650,600,228,229,401,496,703,205,376 steps — to solve a problem, which is a number believed to be larger than all the particles in the universe, then the quantum algorithm providing an exponential speed-up would only take 100 steps. An exponential speedup is so massive that it might dwarf such practical hang-ups as, say, excessive noise.

“Sooner or later, quantum will be faster,” he said. 



HOW’S THAT WORK IN THE REAL WORLD? — Robin Blume-Kohout is leading a team that will develop a variety of methods that will ensure the performance of quantum computers in real-world situations. **Photo by Kevin Young**

Toy drives in New Mexico



TONS OF TOYS — The Labs’ annual Holiday Gift Drive for children in foster care in Bernalillo County (right two photos) delivered 2,466 gifts to 1,050 foster children, said Roberta Rivera of Community Involvement. At the same time, Sandia staff donated more than 1,000 toys — more than double last year’s total — to the annual Toys for Tots campaign sponsored by the U.S. Marine Corps Reserve (left two photos), along with \$2,000, said Carl Unis of complex systems. **Photos by Randy Montoya**

Sandia/California donation helps support 9,500 meals in Bay Area

\$4,000 supports Alameda County Community Food Bank

Story and Photo by **Michael Padilla**

Sandia presented Alameda County Community Food Bank with a \$4,000 donation on Dec. 11, 2018, made possible by Sandia’s Family Stability grant funds.

“Recognizing that many families live with food insecurity in the Bay Area, and that the holiday season can be an extremely difficult time, we are hopeful that this contribution will help provide meals to individuals and families in need,” said Sandia Associate Labs Director Dori Ellis. “Sandia National Laboratories is committed to helping the community.”

Juan Francisco Orozco, Alameda County Food Bank Corporate and Foundation Relations Officer, said he was grateful for the donation.

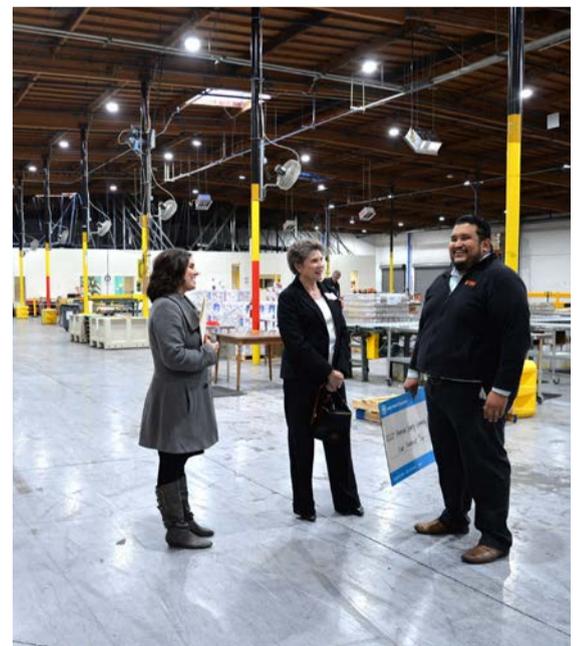
“Sandia National Laboratories’ support will positively impact our food programs,” Orozco said, “With your grant we will be able to purchase

and distribute more than 9,500 meals to hungry families this holiday season.”

The Alameda County Community Food Bank helps alleviate hunger by distributing food throughout the county. The food bank distributes food through its 200+ member agency network. Partners in the food distribution program include food pantries, hot meal programs, senior centers, college campuses and others. The food bank is able to convert every dollar donated to \$7 worth of food.

Orozco said the food bank encourages member agencies to distribute healthy food and to select the foods that match the preferences of the clients they serve. The food bank has a commitment to provide fresh produce at no charge. Produce is scarce in most low-income neighborhoods in Alameda County.

The food distribution program benefits one in five Alameda County residents — a total of 311,000 people, including 21,000 children. This year, the food bank is providing nearly 120 million meals to those in need. 



TOURING THE FOOD BANK — Kayla Norris, Sandia/California community relations specialist (left), and Associate Labs Director Dori Ellis tour the Alameda County Community Food Bank with Juan Francisco Orozco, the food bank’s Corporate and Foundation Relations Officer.

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Microneedles technique

CONTINUED FROM PAGE 1

the Defense Threat Reduction Agency and Sandia's Laboratory Directed Research and Development program.

"We believe interstitial fluid has tremendous diagnostic potential but there has been a problem with gathering sufficient quantities for clinical analysis," Ronen said. "Dermal interstitial fluid, because of its important regulatory functions in the body, actually carries more immune cells than blood, so it might even predict the onset of some diseases more quickly than other methods."

Ronen, along with University of New Mexico, the U.S. Army Edgewood Chemical Biological Center and other Sandia researchers described the new technique in an Oct. 22 paper in the Nature journal, Communications Biology.

The relatively large quantities of pure interstitial fluid extracted, which have never before been achieved, make it possible to create a database of testable molecules, such as proteins, nucleotides, small molecules and other cell-to-cell signaling vesicles called exosomes. Their presence or absence in a patient's interstitial fluid would then indicate, when an individual's data is transmitted by electronic means to a future data center, whether bodily disorders like cancers, liver disease or other problems might be afoot.

The new microneedle extraction protocol achieved its latest results by modifying a technique described in a 1999 technical paper. The original technique drew fluid with a microneedle attached to a flat substrate penetrating the skin. In the recent modification, a concentric ring from a horizontally sliced insulin pen injector surrounding the needle was used serendipitously, and a far greater amount of fluid became available.

"The earlier paper showed less than a microliter per insertion and our new needles were getting up

to 2 microliters per needle, so we hypothesized the difference had to be the mounting around the needle modulating the pressure pressed on the skin," said Sandia researcher Philip Miller, the lead author on the paper. "By creating arrays of needles, our extractable amount increased from 2 microliters to up to 20 microliters in human subjects." One microliter is about 0.000034 fluid ounces.

Interstitial fluid, the transparent fluid that surrounds all our cells, is most commonly experienced as the liquid that puffs up blisters. It is so important for the transport of biomolecules between cells and as an intermediary between blood and the lymphatic system that some researchers have referred to it, like skin, as another bodily organ.

Interstitial fluid's advantage for patients is that it can be probed by 1.5-millimeter (approximately .06 inches) needles that are too short to reach nerves that cause pain. It also has no red blood cells to cloud the results of tests. Until this latest research, the fluid had only one difficulty: the inability of researchers to collect enough of it unspoiled by cell fragments to perform an adequate number of tests for complete characterization. A microneedle pressed into the skin would send up just the interstitial fluid it had displaced — a fraction of a microliter. Alternatively, inserting a tiny fluid pump brought forth large but damaged quantities of fluid.

Million-dollar research agreement

Work over the last decade has used the needles in the laboratory to collect tiny amounts — fractions of microliters — of interstitial fluid to detect in real-time changes in body salts that indicate fatigue. Researchers envisioned a wristwatch-sized device that gave instant electrolyte readouts to athletes and their coaches, military personnel in the field or ordinary citizens feeling a bit down.

That technique has proved of more than theoretical interest: Sandia Labs, with Ronen as lead

investigator, has just signed a \$1 million Cooperative Research and Development Agreement with an Australia-based company, Microfluidics Biomedical Pty. Ltd., to develop just such a watch that senses lactate and glucose in real time. The watch is projected to be market-ready within three years. Ronen spoke about this concept in a TEDxABQ talk in September 2017.

The agreement is based upon the company's interest in creating a real-time measurement device for sports enthusiasts, soldiers in the field and ordinary people interested in determining personal health issues immediately. The company's expertise in algorithm development and Sandia's expertise in microfabrication of autonomous integrated sensors and microneedle technology will join in the product's development.

Various watch designs will be tested for sensitivity and selectivity, as well as for long-term use over relevant concentration ranges in a synthetic interstitial fluid and then in live subjects. Microfluidics Biomedical will design the wireless technology for transmitting the signal generated by the sensors, which can be read by coaches, military team leads, or the person who owns the watch.

The research agreement is significant because it is a step in crossing what entrepreneurs call the "valley of death" that often separates laboratory innovation from realization as a commercial product.

But the research community investigating the medical use of microneedles wanted to examine bigger game, including detecting dread diseases more intrusive than a mere shortage of electrolytes.

More tests will be needed to collect data on those interstitial fluid components that mirror in kind, though not in quantity, many of those available for blood. Once achieved, the stage will be set for simpler, cheaper, faster, painless tests expected in the future to be transmitted electronically from a participant's wrist watch to a central data bank, to determine in real-time the existence of a medical problem and its remedy at the earliest stage.

It will take many years to make a complete database for the world's diseases, Ronen said. So he and his team are starting a new project to look at biomarkers in interstitial fluid that evolve after flu vaccinations. The effort will use volunteer Sandia employees.

"Flu vaccinations are an ideal way to study the pathogenesis of infectious diseases, and this study can lead to a new way to diagnose influenza and characterize its spread," Ronen said. 

Sandia Labs has signed a \$1 million Cooperative R&D Agreement to develop a watch that senses lactate and glucose in real-time.

Mileposts



New Mexico photos by Michelle Fleming
California photos by Randy Wong



Larry Dishman 45



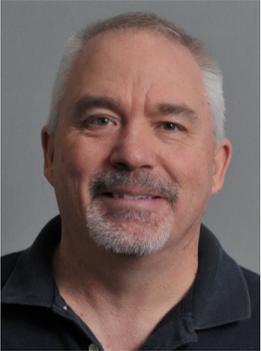
Mike Pendley 45



Dave Trujillo 40



Scott Nicolaysen 35



John Schwartz 35



Robert Anderson 30



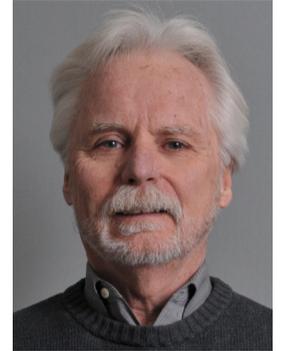
Jim Berg 30



John Dye 30



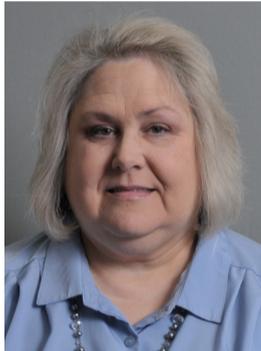
Tim Knewitz 30



Kevin McMahon 30



Phil Sackinger 30



Nancy Aldridge 25



Sarah Allendorf 25



Ken Chen 25



David Evensky 25



Susanna Gordon 25



Nicole Morgan 25



Randy Clarin 20



Jeremy Dencklau 20



Angela Griffin 20



Brian Post 20



Jason Stamp 20

Recent Retirees



New Mexico photos by Michelle Fleming
California photos by Randy Wong



Lonnie Trujillo 40



William Prgent 40



Barbara Bays 39



Pat Smith 35



Ron A. Martinez 35



Raymond Dukart 34



Tia Reid 34



Fran Current 33 Karen Current 33



Alan Armentrout 30



Mark Mitchell 30



Tammie Muniz 26



Michael Benson 25



Carol Michaels 25

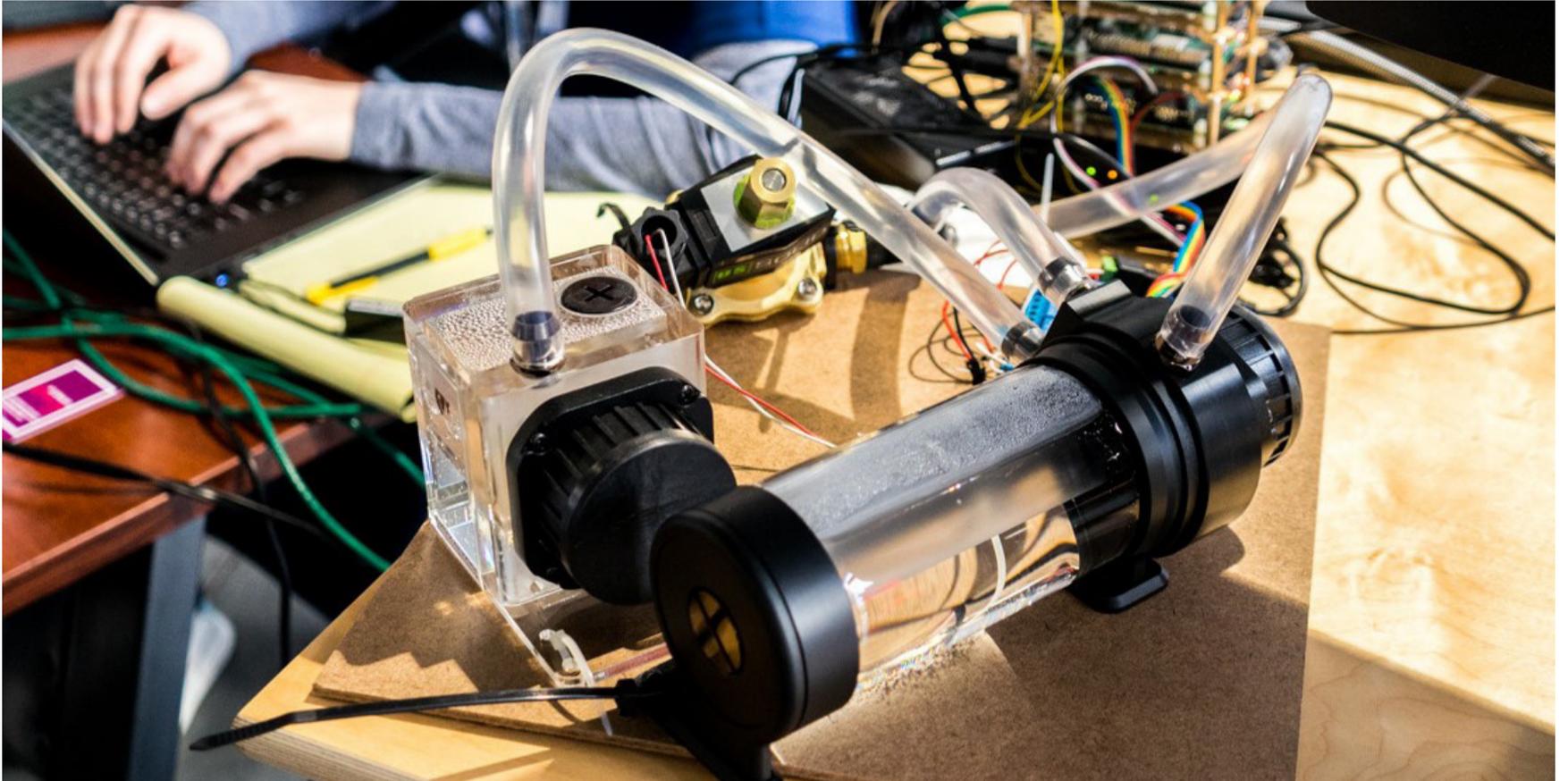


Marlene Brown 21



Cary de la Fe 18

Sandia staff engages in cyber wargames with college students



PUMPED UP — A small pump cycles water between tanks to represent a large-scale, critical infrastructure system. Anomalies in the system occasionally tipped off students to suspicious activity on the network.

by **Troy Rummler**
Photos courtesy of **Paul Billman**

More than 60 colleges and universities competed to defend fictional energy systems from pretended hackers at DOE's annual CyberForce Competition last month. Sandia served as a host for the first time, and organized in Albuquerque one of seven simultaneous, regional competitions across the country.

Each year, the DOE competition raises awareness of security challenges facing the nation's critical energy infrastructure and gives students practical experience protecting simulated industrial systems, using scenarios based on real-world cybersecurity issues.

"We need to develop the next generation's expertise so that they are combining the disciplines of cybersecurity and power engineering," said Adrian Chavez from threat intelligence. "Because right now, these fields are mostly segregated, but they are rapidly converging in operational settings."

That segregation exists partly because many critical systems — such as oil and water pipelines, energy grids and emergency response systems — are decades old. At the time they were built, security typically meant physically isolating them from other electronic systems. Thus, information technology and the technologies used in operating the systems evolved separately.

Today, to take advantage of new, internet-based technology, the systems need professionals who speak both languages.

CyberForce is one effort to bridge that gap.

Teams take up battle stations

This year, each team protected an oil transport system, physically represented by a small, two-tank water pump electronically connected to a stack of Raspberry Pi computer nodes, which served as the industrial control system. A squad of volunteers, secreted elsewhere in the building and posing as regular users, could access the system through the competition's server to perform such tasks as manually running the pump or changing the flow rate.

So could the hackers, if the students weren't careful enough.

"Essentially, we want to try to be as stealthy as

we can," Jayson Grace said. "We, the New Mexico red team, want to try to get into the blue team's [students'] systems and stick around—persist—so that when the competition ends, we can just 'rm -rf /', and you know, destroy everything." Persistence, he explained, reflects what students should expect to see in the real world. Jayson's group mixed brute-force attempts to guess passwords and similar clumsy attacks with other, subtler techniques.

"There are various timed vulnerabilities, such as rogue backdoors that start up on a certain port at a specific time in the competition, for which we created automated attacks," he said. "Several red team members have been successful in breaking into their target teams' systems, so essentially that means as soon as that service came online, we hit it and got root."

Instant gratification, Jayson called it.

Recreating a high-consequence scenario

"We used simulated systems in the competition to learn about critical infrastructure security," said Adrian, who built the system used in the competition. "The goal was familiarizing students to work on securing our nation's critical infrastructure systems, which if not properly secured and exploited, could result in severe consequences.

Security for consumer electronics is rarely so dire. When a circuit breaker tripped early in the second day of the competition, computers lost power. Students were surprised and inconvenienced, but they found a quick remedy with the aid of a few extension cords, and the competition resumed.

The stakes of securing the nation's critical infra-

structure systems are much higher, said Han Lin, who managed the Albuquerque event. "Imagine you're running an airport, directing traffic, and your whole system goes down," he said. "How do you direct all these planes to land safely?"

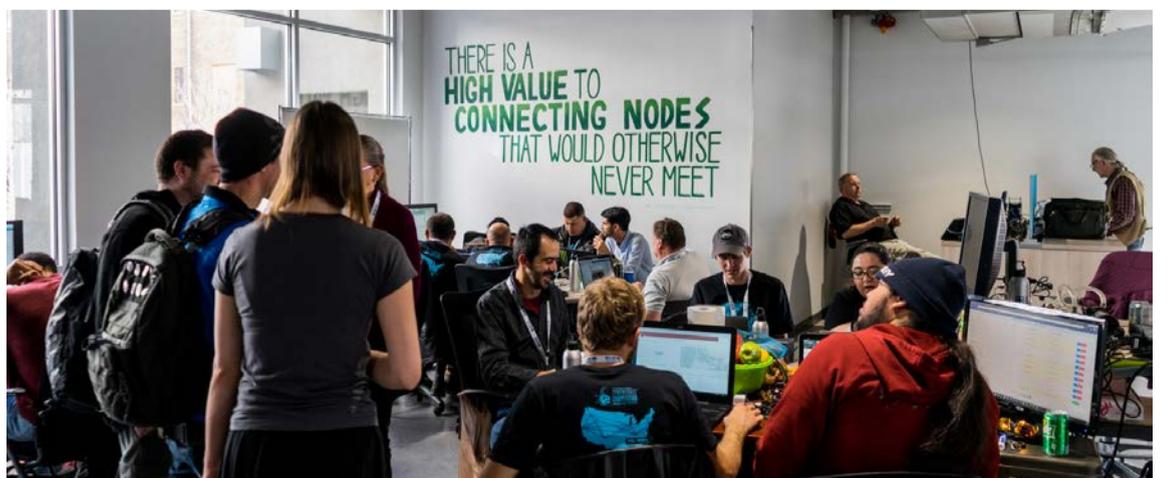
Teams were mainly scored on their ability to boot hackers and minimize service interruptions. If users found a system wasn't responding properly or they couldn't access documentation, they punished the defenders with negative surveys, lowering their score.

Participants had a chance to earn points in the Phish Tank, where cybersecurity professionals interviewed each team and scored them on the ingenuity of their defensive strategy. There were also anomalies, distraction challenges that took participants away from their main task. When one student left his team to take care of one, he came back wearing a paper crown.

All part of the game

Government officials showed interest in the competition. Dimitri Kusnezov, the NNSA's chief scientist and senior adviser to DOE Secretary Rick Perry, attended the Albuquerque event, as did congressional staffers on behalf of Governor-elect and New Mexico Governor-elect Michelle Lujan-Grisham, U.S. Representative Ben Ray Lujan, and U.S. Senators Tom Udall and Martin Heinrich. Energy Secretary Perry delivered opening remarks by video.

The student team from Southern Methodist University of Dallas, Texas, won the Albuquerque regional competition and placed 14th overall. The national winner was the University of Central Florida. 



MAY THE CYBERFORCE BE WITH YOU — Student teams collaborate to fend off hackers and appease the end users of a simulated oil-transport system.

Sandia staff engages in cyber wargames with college students



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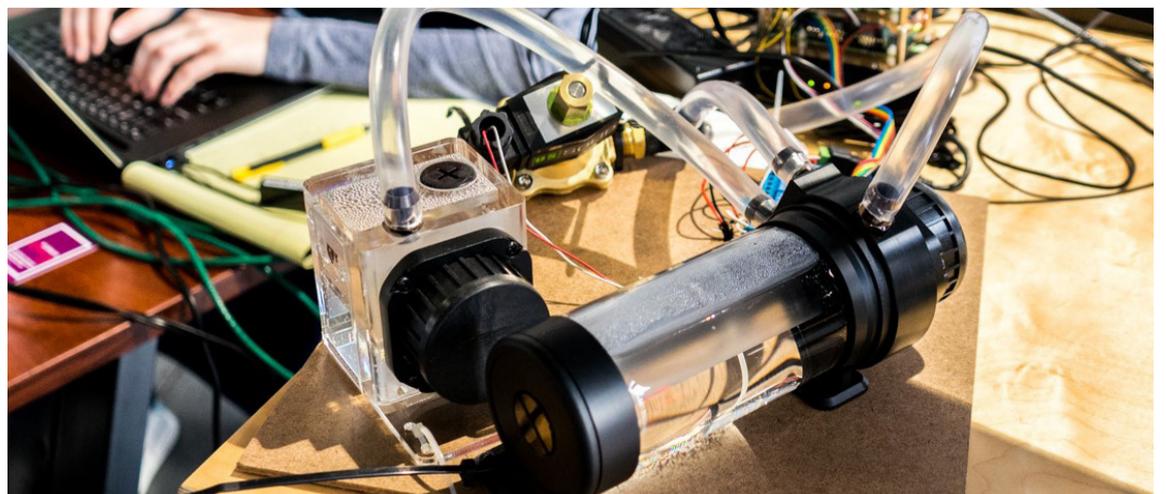
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