SANDIA LABNEWS
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Steadying the hands of time

Innovative Methodologies

LASER SHOW — Dan Thrasher looks to his computer monitor while setting up an optical table at Sandia, where he is testing lasers in combination with barium ions to reduce drift in miniature atomic clocks, making them more accurate. **Photo by Craig Fritz**

US-Japanese partnership approaches an atomic clock breakthrough

By **Troy Rummler**

All clocks are ticking down to an argument about the time. Imperceptibly, they gain or lose fractions of a second. Gradually, they drift apart until someone reads the time aloud, and somebody with a different clock begs to differ.

Unless clocks are periodically synchronized, drift is just a fact of life. Even super accurate atomic clocks experience drift. While not as much as a cheap bedroom alarm clock, it is still enough to catch the

— CONTINUED ON PAGE 3

The mother of all motion sensors

Quantum sensing milestone draws closer exquisitely accurate, GPS-free navigation

By **Troy Rummler**

Peel apart a smartphone, fitness tracker or virtual reality headset, and inside you'll find a tiny motion sensor tracking its position and movement. Bigger, more expensive versions of the same technology, about the size of a grapefruit and a thousand times more accurate, help navigate ships, airplanes and other vehicles with GPS assistance.

Now, scientists are attempting to make a motion sensor so precise it could minimize the nation's reliance on global positioning satellites. Until recently, such a sensor — a thousand times more sensitive than today's navigation-grade devices — would have filled a moving truck. But advancements are dramatically shrinking the size and cost of this technology.

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PREPARING THE EXPERIMENT — Sandia scientist Jongmin Lee, left, prepares a rubidium cold-atom cell for an atom interferometry experiment while scientists Ashok Kodigala, right, and Michael Gehl initialize the controls for a packaged single-sideband modulator chip. **Photo by Craig Fritz**

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Sandia National Laboratories

Albuquerque, New Mexico 87185-1468
Livermore, California 94550-0969
Tonopah, Nevada | Kauai, Hawaii
Amarillo, Texas | Carlsbad, New Mexico | Washington, D.C.

Katherine Beherec, Editor kgbeher@sandia.gov
Ray Johnson, Production rbjohns@sandia.gov
Craig Fritz, Photographer cvfritz@sandia.gov
Michael Langley, California Contact mlangle@sandia.gov

CONTRIBUTORS

Michelle Fleming (milepost photos, 505-844-4902), **Neal Singer** (505-846-7078), **Kristen Meub** (505-845-7215), **Troy Rummler** (505-284-1056), **Meagan Brace** (505-844-0499), **Mollie Rappe** (505-288-6123), **Skyler Swezy** (505-850-2063), **Kim Vallez Quintana** (505-264-1886), **Kenneth Vigil** (505-537-1528), **Luke Frank** (505-844-2020), **Michael Baker** (505-284-1085) **Maggie Krajewski** (mkrajew@sandia.gov), **Valerie Alba** (vnalba@sandia.gov), **Lea Blevins** (lsblevi@sandia.gov)

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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 the Lab News editor at labnews@sandia.gov.

USSTRATCOM commander and NNSA administrator address Sandians

VIP HUDDLE — Laboratories Director James Peery, right, hosted Jill Hruby, NNSA administrator, left; Gen. Anthony Cotton, commander of U.S. Strategic Command, center; and Marv Adams, NNSA deputy administrator for Defense Programs, on July 15. **Photo by Craig Fritz**

By **Kenny Vigil**

In a packed auditorium at Sandia's New Mexico site, Gen. Anthony Cotton, commander of U.S. Strategic Command, and NNSA Administrator Jill Hruby delivered a stark message about the evolving security landscape. Unlike the Taliban and ISIS, adversaries like Russia and China pose different and more complex threats.

"There are folks who just want to undermine and destroy international laws and norms," Cotton said. "I need your help."

Cotton and Hruby presented "Today's Strategic Environment" July 15 to an audience that included both in-person and virtual attendees. Their daylong visit underscored the urgency of accelerating nuclear deterrence efforts.

"The adversary is not going to wait for us," Cotton said. "We have to figure out how to get this done faster."

Cotton spoke of ongoing efforts to understand North Korea's

STRATCOM VISIT — Gen. Anthony Cotton discusses the geopolitical landscape and why Sandia's work is critical to the security of the U.S. and its allies during a July 15 visit to the New Mexico site. **Photo by Craig Fritz**

FAMILIAR TERRITORY — NNSA Administrator Jill Hruby co-presented "Today's Strategic Environment" during her July 15 visit to the Labs. "It's great to be back with so many colleagues and friends," the former Labs Director said, before updating Sandians about some of NNSA's priorities related to nuclear deterrence. **Photo by Craig Fritz**

relationship with Russia and its implications for the U.S. and its allies. He added that while the U.S. was focused on fighting the Taliban and ISIS, Russia was building up its strategic deterrence forces.

Cotton started and ended his portion of the hourlong presentation by acknowledging Sandia's work.

"I will continue to say, 'Thank you.' The work you're doing here is incredibly important," he said. "The work you do here is challenging, but your hard work is crucial. What you do every day strengthens our national security and makes the world a safer place."

Science and deterrence

Administrator Hruby echoed Cotton's sentiments, stressing the importance of maintaining a credible deterrent.

"Science is a major part of deterrence," she said. "We can't let our science degrade. They copy our science and they're right that we know what we're doing."

Hruby detailed the nuclear security enterprise's collaboration with DOD on seven programs of record, including the B61-12 and the W88 Alt 370, which are now in the production phase.

"We have a really demanding program of record," said Hruby, a former Sandia Labs Director. "We need to go faster, but we're doing a good job. The modernization we have to do going forward is harder than the modernization we had to do in the past."

Hruby said one area of focus is the need for robust infrastructure to support future capabilities, including space, equipment and technology.

When asked how Sandia can deliver faster, she responded, "We have the best workforce distribution in terms of experience that we've had in a long time in NNSA. Let's make it work for us instead of against us." She encouraged employees to bring forward their ideas.

Hruby also underscored the role modern engineering — one of Sandia's two big goals — will have on success.

"Sandia is leading a digital engineering effort," she said. "I'm grateful Sandia has stepped up to lead this — it's a complex-wide activity. It's important to our future."

Atomic clock

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attention of Dan Thrasher, a scientist at Sandia, who believes he can create a better one.

Dan is working with Japanese tech company Nichia Corporation to build the world's most accurate compact atomic clock. These clocks, currently about the size of a matchbook, are used in a variety of technologies from backpack radios, GPS receivers, underwater sensors, power grids and satellites. Any drift they experience limits the time these technologies can run on their own without help from a reference clock.

His project is supported by the Defense Advanced Research Projects Agency, or DARPA, through a program called H6. The Defense Department research agency is known for funding high-tech projects with national security applications, like night vision goggles that fit like sunglasses and surveillance implants for insects.

Improving the world's smallest atomic clock

According to Dan, scientists have been trying to do what he is doing for the past two decades since the creation of the chip-scale atomic clock, or CSAC (pronounced "sea sack"). The matchbook-sized ticker holds the title of the world's smallest commercial atomic clock.

"What made it possible was a very small, very stable, very efficient laser," he said.

The laser is finely tuned to just the right wavelength to tickle atoms of the element cesium, part of an intricate setup that locks in a precise timekeeping rhythm. It was first demonstrated at Sandia.

But the record-holding clock isn't perfect.

"While a CSAC is small and important, it is still subject to sources of systematic uncertainty. The clock drifts over time," Dan said.

Since 2008, researchers at Sandia have been working on miniaturizing a more accurate, albeit larger, type of timepiece called a microwave ion clock.

"In general, a microwave ion clock experiences less drift than a CSAC," Dan said.

Sandia's proposed clock would use electrically charged ions of ytterbium instead of cesium. However, no one has been able to demonstrate a small, stable and efficient ultraviolet laser required to operate it.

Partnership with Japanese company revitalizes research

Unknown to these researchers, Nichia had been making advancements in small laser technology. Its scientists successfully developed a very small, stable and efficient violet-blue laser for displaying information inside smart glasses.

The laser was the same variety used in CSACs, called a vertical cavity surface emitting laser, or VCSEL (rhymes with "pixel"). What's more, "Nichia had been looking for a new opportunity to showcase the value of its VCSEL with violet-blue wavelength," a Nichia spokesperson said.

Dan lit up when he read a research paper about the laser. Although its wavelength was no good for ytterbium ions, it closely matched the wavelength required for ions of another element — barium.

Barium was nobody's first choice. As far as elements go, it is equal parts stubborn and sensitive. The last time scientists used barium to demonstrate a microwave ion clock was in 1985.

"Before I was born," Dan said.

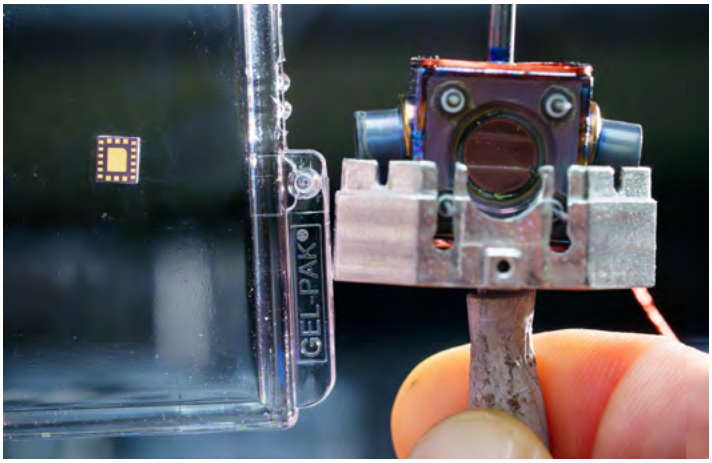
"There are very valid reasons to disregard barium. But we have the cat's meow of laser technology at the right wavelength, and that alone is enough motivation for us to try to develop this," he said.

Dan was confident he could use Nichia's laser to build an atomic clock based on barium ions that is smaller and more accurate than the CSAC.

"There are some projects I would put my own money into. This is one of them," he said.

He shared his idea with Nichia and DARPA.

"Nichia gladly accepted Sandia's offer to support their study because Nichia felt this compact, low-power-consumption, single-frequency laser diode would be a key technology for the small atomic clock Sandia is targeting," the spokesperson said.



TICK TOCK STARS — A miniature laser package for housing multiple 455 nanometer VCSELs, left, and a 3 cubic centimeter vacuum package for trapping and interrogating ions, right, are two critical components required for a buffer-gas-cooled microwave ion clock at Sandia. **Photo by Craig Fritz**

Bumpy start gives way to successful tests

The switch to barium was not as simple as Dan had hoped. After boldly defending his proposal as low-hanging fruit, initial tests revealed that the laser deteriorated faster than expected, which meant the clock could be rendered useless after just a short time.

"That scared me," he said.

But further studies soothed his nerves. After a longer-than-expected "burn-in" time, the rate of deterioration stabilized, indicating that the laser would stay healthy for a long time.

In June, Dan successfully used Nichia's laser to optically detect barium ions and presented his research at the European Frequency and Time Forum in Neuchâtel, Switzerland. While this is not the same as measuring time, it demonstrates the laser possesses all the necessary qualities to operate the clock. The research itself holds potential value for certain types of quantum computing, where lasers are used to make precise measurements of trapped ions.

"This is the first time anyone has used light from a VCSEL to detect trapped ions," he said.

Dan is enthusiastic about the future of his project.

"The light source is clearly the bottleneck in commercializing miniature microwave ion clocks. We are closer than ever before to solving this problem."

Innovation takes time

Failure to demonstrate a light source suitable to enable a miniature microwave ion clock plagued Dan and others for years. He credits finding the path he is on now to program development funds that gave him the time to review recent relevant literature and respond to a call for proposals from a funding agency.

Although scientists and engineers are often busy and driven by deadlines, "The reason I found this resource (Nichia Corporation) was because I took the time to read the literature," he said. "When you're doing cutting-edge research, it's crucial to be aware of your field and be involved in your research communities."

It turns out scientists, like clocks, work better when they are in sync.

Quantum sensing

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For the first time, researchers from Sandia have used silicon photonic microchip components to perform a quantum sensing technique called atom interferometry, an ultra-precise way of measuring acceleration. It is the latest milestone toward developing a kind of quantum compass for navigation when GPS signals are unavailable.

The team published its findings and introduced a new high-performance silicon photonic modulator — a device that controls light on a microchip — as the cover story in the journal Science Advances.

The research was supported by Sandia's Laboratory Directed Research and Development program. It took place, in part, at the National Security Photonics Center, a collaborative research center developing integrated photonics solutions for complex problems in the national security sector.

GPS-free navigation a matter of national security

"Accurate navigation becomes a challenge in real-world scenarios when GPS signals are unavailable," said Sandia scientist Jongmin Lee.

In a war zone, these challenges pose national security risks, as electronic warfare units can jam or spoof satellite signals to disrupt troop movements and operations.

Quantum sensing offers a solution.

"By harnessing the principles of quantum mechanics, these advanced sensors provide unparalleled accuracy in measuring acceleration and angular velocity, enabling precise navigation even in GPS-denied areas," Jongmin said.

Modulator the centerpiece of a chip-scale laser system

Typically, an atom interferometer is a sensor system that fills a small room. A complete quantum compass — more precisely called a quantum inertial measurement unit — would require six atom interferometers.

But Jongmin and his team have been finding ways to reduce its size, weight and power needs. They already have replaced a large, power-hungry vacuum pump with an avocado-sized vacuum chamber and consolidated several components usually delicately arranged across an optical table into a single, rigid apparatus.

The new modulator is the centerpiece of a laser system on a microchip. Rugged enough to handle heavy vibrations, it would replace a conventional laser system typically the size of a refrigerator.

Lasers perform several jobs in an atom interferometer, and the Sandia team uses four modulators to shift the frequency of a single laser to perform different functions.

However, modulators often create unwanted echoes called sidebands that need to be mitigated.

Sandia's suppressed-carrier, single-sideband modulator reduces these sidebands by an unprecedented 47.8 decibels — a measure often used to describe sound intensity but also applicable to light intensity — resulting in a nearly 100,000-fold drop.

"We have drastically improved the performance compared to what's out there," said Sandia scientist Ashok Kodigala.

Silicon device mass-producible and more affordable

Besides size, cost has been a major obstacle to deploying quantum navigation devices. Every atom interferometer needs a laser system, and laser systems need modulators.

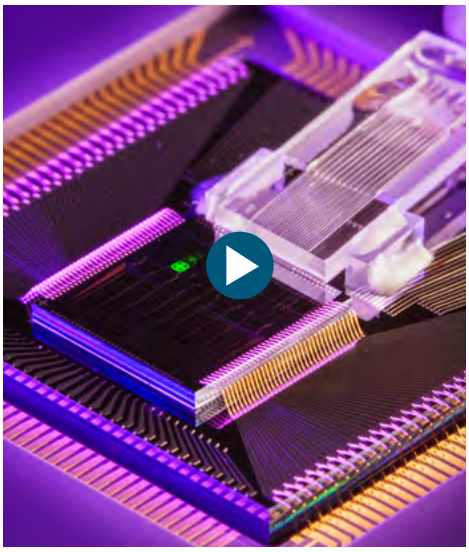
"Just one full-size single-sideband modulator, a commercially available one, is more than $10,000," Jongmin said.

Miniaturizing bulky, expensive components into silicon photonic chips helps drive down these costs.

"We can make hundreds of modulators on a single 8-inch wafer and even more on a 12-inch wafer," Ashok said.

And since they can be manufactured using the same process as virtually all computer chips, "This sophisticated four-channel component, including additional custom features, can be mass-produced at a much lower cost compared to today's commercial alternatives, enabling the production of quantum inertial measurement units at a reduced cost," Jongmin said.

As the technology gets closer to field deployment, the team is exploring other uses beyond navigation. Researchers are investigating whether it could help locate underground cavities and resources by detecting the tiny changes these make to Earth's gravitational force. They also see potential for the optical components they invented, including the modulator, in LIDAR, quantum computing and optical communications.



MINI MODULATOR — Sandia's four-channel, silicon photonic single-sideband modulator chip, measuring 8 millimeters on each side and marked with a green Sandia thunderbird logo, sits inside packaging that incorporates optical fibers, wire bonds and ceramic pins. **Photo by Craig Fritz**

Multidisciplinary team lifting quantum compass concept to reality

Jongmin and Ashok represent two halves of a multidisciplinary team. One half, including Jongmin, consists of experts in quantum mechanics and atomic physics. The other half, like Ashok, are specialists in silicon photonics — think of a microchip, but instead of electricity running through its circuits, there are beams of light.

These teams collaborate at Sandia's Microsystems Engineering, Science and Applications complex, where researchers design, produce and test chips for national security applications.

"We have colleagues that we can go down the hall and talk to about this and figure out how to solve these key problems for this technology to get it out into the field," said Peter Schwindt, a quantum sensing scientist at Sandia.

The team's grand plan — to turn atom interferometers into a compact quantum compass — bridges the gap between basic research at academic institutions and commercial development at tech companies. An atom interferometer is a proven technology that could be an excellent tool for GPS-denied navigation. Sandia's ongoing efforts aim to make it more stable, fieldable and commercially viable.

The National Security Photonics Center collaborates with industry, small businesses, academia and government agencies to develop new technologies and help launch new products. Sandia has hundreds of issued patents and dozens more in prosecution that support its mission.

"I have a passion around seeing these technologies move into real applications," Peter said.

Michael Gehl, a Sandia scientist who works with silicon photonics, shares the same passion. "It's great to see our photonics chips being used for real-world applications," he said.

"I think it's really exciting," Ashok said. "We're making a lot of progress in miniaturization for a lot of different applications."

Little Boy postwar history mystery enthralls 75th Speaker Series crowd

By **Jim Danneskiold**

Historian Alex Wellerstein offered fascinating insights into the intricacies of his research into the early days of nuclear weapons in his talk, "Little Boy After Hiroshima," the second in the 75th Anniversary Speaker Series.

Wellerstein, a professor at the Stevens Institute of Technology in New Jersey, spoke last week to an audience of about 500 Sandians at the Steve Schiff Auditorium and online.

His interest began with the big question of how the U.S. nuclear weapons stockpile evolved. While researching the immediate postwar period for a book on nuclear policymaking in the Truman administrations, he became fascinated with trying to find out how many Little Boy-type fission weapons the U.S. produced besides the one dropped in Hiroshima in August 1945.

Early on, he said, weaponeers at Los Alamos National Laboratory were extremely dismissive of Little Boy, seeing the uranium gun-type bomb as a hedge against possible failure of the program to build the more complex Fat Man plutonium bomb, and a potential tool for future specialized missions. By late 1945, they considered it definitely "obsolete," as it required much more fissile material to achieve an even lower explosive yield than Fat Man.

THE NUCLEAR STOCKPILE: EARLY DAYS — Historian Alex Wellerstein tells Sandians at the Steve Schiff Auditorium about his fascination with the early stockpile and the number of gun-type, or Little Boy, weapons that the U.S. produced. **Photo by Craig Fritz**

By spring 1946, however, documents showed a change: "Little Boy is apparently desired in the stockpile," due to plutonium production issues at Hanford, Wellerstein said. Later that year, the Navy made clear its interest in deploying it on aircraft carriers.

Often overlooked was Sandia's role in those early days, he said, principally focused on moving weapon designs and developments such as the postwar Little Boy through the engineering phase and onto "The Road" to military deployment.

Scouring a range of declassified documents and linking them to highly enriched uranium production reports and a variety of other early government charts, Wellerstein wove a picture of what this "retrogression" in the early stockpile tells us about the complex and uncertain postwar period, and how the modern nuclear weapons complex evolved.

He concluded that obsolescence for Little Boy was a matter of context. Though less efficient than Fat Man, circumstances led different groups to determine it was desirable to add a small number of Little Boys to the postwar stockpile.

How many were added remains somewhat inconclusive due to conflicts in the many sources and documents, though the early stockpile included components of a couple of dozen Little Boys. Wellerstein said that it appears that as many as 10 weapons may have been available by 1950, but that even that number was dependent on uncertain definitions.

"What do we mean by a Little Boy bomb?" he asked. "What do we even mean by the stockpile? We have a little bit of this and a little bit of that."

HISTORY LOVERS — Wellerstein spent nearly half an hour after his talk meeting Sandians and discussing early weapons history. **Photo by Bret Latter**

Hemlines and blue jeans: Sandia's fashion evolution

By **Maggie Krajewski**

When Sharon Mackel started at Sandia as a secretary in the 1960s, women in the workforce were expected to wear a full face of makeup, dresses with hemlines below the knee, nylons and heels.

Sharon remembers a supervisor at the time who would call out secretaries who did not wear lipstick properly. That same supervisor approached Sharon for wearing her hemline too short, but hemlines and lipstick would be the least of the fashion trends to evolve in the coming decade.

"They tried to control how we dressed, but it was a weird time as we were coming into the hippy era," Sharon said. "Things started getting really loose."

The '50s and '60s

Scrolling through early editions of Lab News, you see men mostly dressed in button-downs and pleated slacks belted high on their waists. When they wore sports coats, the lapels were wide, and the ties were bows. Hair was styled mostly neat and trim, but as Elvis Presley and James Dean were fashion icons of that era, those with enough of it sported a well-greased pompadour.

Marilyn Monroe and Elizabeth Taylor, also fashion icons of that era, inspired women to wear some variation of an hourglass silhouette with hemlines right below the calf. Hair rollers were the primary hair styling tool at that time, so hair was big yet smooth. Those with natural curls often turned to the poodle cut, inspired by Lucille Ball, where curls were stacked high with sides pinned close.

Things stayed relatively the same through the '50s and '60s. Twiggy and Jackie Kennedy came onto the scene in the '60s, and their influence was a little less Hollywood glamour, more European chic. Hemlines started to come up a bit, albeit still right below or barely above the knee. For men, pants stayed high, but sports coats seemed to be less popular and the ties got skinnier.

STYLE SHOWCASE — Dresses modeled from a 1954 Mother's Day Fashion Show.
Photo from the Lab News archives

Polyester and sideburns

Sharon remembers dress changing rapidly in the '70s, especially for women.

"There was a group of us who lived on the second floor in building 805, we started challenging the norm," Sharon said. "We stuck together and started wearing pantsuits to work, shorter skirts, like miniskirts. I even wore hot pants to work one day."

Sharon and those hot pants were pictured in a 1971 edition of Lab News. She's also wearing a long sleeve turtleneck and lace-up high boots. Also noticeable is her hair, which is much longer, falling below her shoulders. Influenced by the likes of Farrah Fawcett and Cher, many women started growing their hair long and wearing it straight or feathered out.

Both men and women were wearing brighter, more vibrant patterns, think floral, paisley and plaids. More clothing was made from polyester, which at the time was marketed as a miracle fabric that could be worn for days without ironing and still look presentable. Leisure suits were an especially popular polyester pick.

BUTTONED UP — A look at men's workwear from 1959. **Photo from the Lab News archives**

WOMEN'S FASHION — Models show off the latest trends in 1967.
Photo from the Lab News archives

Turtlenecks under sports coats became a popular look for men, as did wide-legged pants. Wide ties returned to fashion, but due to southwest influence, many men swapped more traditional ties for bolo ties. Most noticeably, facial hair became more mainstream. Scrolling through Lab News editions from the '70s, you'll see men with thick mustaches and full beards. Men started wearing their hair longer as the Beatles, David Cassidy and John Travolta inspired many hairstyles of that era. For those who kept their hair short, thick sideburns were commonplace.

HOT PANTS — Sharon Mackel models one of the looks from Omar's Boutique featured at a fall fashion show in 1971.

Photo from the Lab News archives

Shoulder pads and perms

Once the eighties rolled around, everything seemed to get bigger. The hair, the glasses, the shoulder pads — especially the shoulder pads.

"Dynasty" starring Linda Evans was one of the popular television shows at the time. Costume designer Nolan Miller is said to have leaned into Evans' naturally broad shoulders, really wanting to accentuate them. And a fashion trend was born.

Princess Diana of Wales was another well-known trendsetter of the era. A fellow shoulder pad lover, she also popularized many looks chosen by women at the Labs and beyond, including piecrust and tie-neck blouses and dresses.

Then there was the hair, and the perm.

If there was an official hairstyle of the '80s, the perm would have been it. Those tiny curls and the volume they created were everywhere, on men and women alike.

Men at the Labs were wearing more and more denim, first with their jeans and now with their jackets too. Polo shirts were also popping up as a casual alternative to the button down.

THAT '70S LOOK — Pictured left to right, Solia Candelaria, Archie Pearlman, Peggy Stevens, Ken Sutton, Sharon Mackel, Jan Hawkins and Laura Garcia report Sandia's contribution of $344,837 to the Albuquerque United Community Fund at a meeting in 1972. **Photo from the Lab News archives**

Casual Fridays

Compared to the bigger-is-better trends of the '80s, the '90s started to mellow out. But as Sharon recalls, things started getting, and staying, casual.

"Casual Fridays came to Sandia in the '90s," Sharon said. "And then it started stretching out past Friday."

Once considered weekend wear, T-shirts and crewneck sweatshirts were suddenly popular work attire. But still, for both men and women, you saw remnants of decades past, both in clothing and hairstyles. Blue jeans and blazers, thick ties, bolo ties, no ties, dresses and pantsuits, big hair, short hair, facial hair and no hair.

POLYESTER PATTERNS — Rocky Medina and Terry Caress show off looks to be featured at a summer fashion show in 1974.

Photo from the Lab News archives

MEN IN THE '70s — Above shows a little bit of everything that was stylish for men in the '70s. This specific photo shows Dave Northrop, Wendell Weart and Hap Stoller in 1974.

Photo from the Lab News archives

THE '80s — A look at some of the more popular workwear looks from 1983.

Photo from the Lab News archives

Fashion around the world and at the Labs was becoming a little more choose-your-own-adventure, a lot less about wearing your lipstick correctly.

The 21st century

By the turn of the century, workplace fashion was less dictated by formal standards and more welcoming of varied choices that embraced individual expression.

Today, those choices and expressions continue to borrow from the trends of yesteryear while introducing new styles, some with a longer shelf life than others.

SOUTHWEST STYLE — Pictured in 1988, Joe Padilla shows off a popular look of the time with his full beard, bolo tie and leather sports coat.

Photo from the Lab News archives

THE '90s — A photo from 1990 shows some of the more popular hairstyles and styles for working women in the early '90s.

Photo from the Lab News archives

Popular culture continues to influence hairstyles, outfits and more.

But when we wake up and take on the age-old task of deciding what to wear to work that day, our comfort takes precedence. For some, that means wearing a suit and tie, and for others, it's jeans and tees. But these days, it's all acceptable, and that is in large part due to women like Sharon who challenged the norm and paved the way for us all to wear what we want.

Fashion at the Coronado Club

For almost two decades, the Coronado Club hosted fashion shows throughout the year. Sandia staff, both men and women, would model the latest seasonal trends provided by local clothing boutiques. Scrolling through Lab News from the '50s, '60s and early '70s, you can find articles and photos promoting fashion shows showcasing spring hats, ski clothing, evening gowns and holiday styles.

Around the mid-'70s it appears the fashion shows had run their course as there was no further mention or promotion of them, in Lab News at least. The why is unclear, but Labs Historian Rebecca Ullrich says events such as fashion shows, high teas and dances seemed to wane in later years.

Stan Atcitty recognized for tribal electrification work

By **Mollie Rappe**

Sandia Senior Scientist Stan Atcitty has been honored with the A.P. Seethapathy Rural Electrification Excellence Award by the Institute of Electrical and Electronics Engineers for his leadership and innovation in the rural electrification of U.S. tribal nations.

The IEEE, one of the world's largest technical professional organizations, established the Seethapathy Rural Electrification Award in 2008. The award recognizes exceptional power engineers who have innovated or implemented cost-effective electrification technologies for the rural sector. It is among 24 national awards of the IEEE Power and Energy Society.

Stan, a member of the Navajo Nation, leads the power electronics subprogram as part of the Department of Energy Office of Electricity's Energy Storage Program. He also leads the Tribal Energy Storage Program and the National Nuclear Security Administration's Minority Serving Institution Partnership Program, conducting outreach with tribal colleges and universities.

ELECTRIFYING SPEAKER — Sandia Senior Scientist Stan Atcitty speaks during a visit to Navajo Technical University on June 30, 2023. Stan received an award from the Institute of Electrical and Electronics Engineers for his work with tribal nations providing information as to how they can meet their electrical needs.

Photo by Craig Fritz

"There is a tight connection between electrification and life," Stan said. "In many cases, no electricity means no life for the community. My focus is on the heart of the people, working for their benefit, not mine. True purpose in life is found when we act for the benefit of others."

Stan noted that much work remains to be done. Many tribal communities across the U.S. still have unreliable or limited access to electricity.

Building trust for energy sovereignty

For more than 25 years, Stan has collaborated with tribal nations, offering everything from introductory energy lectures to building relationships and trust, to

providing in-depth technical reports on distributed energy resources and power electronics tailored to each tribe's needs. The technical support is focused on giving each tribe the information they need to make the best decision for themselves, rather than selling a specific technology or solution, he said.

"By informing tribal communities, we empower them to make informed decisions about future renewable energy and energy storage deployments," Stan said. "This is the core of our work. My team and I are dedicated to advancing their energy sovereignty and self-determination to the next level."

Stan is particularly proud of his work with the Seminole Tribe of Florida. Due to their location, the community experiences over 100 power outages annually, mostly from hurricanes and other storms. Stan and his team developed a distributed renewable energy system with storage for key community buildings, such as the hospital and administrative buildings. The system is currently operational, and the tribe is pleased with the results, he added.

Stan's research focuses on power electronics necessary to integrate energy storage and distributed generation with the electric utility grid. He has received seven R&D 100 awards and one Gold Green Energy award from Research & Development magazine. Last year, he was named an IEEE Fellow and has been a member of the organization for more than twenty years. He received a Presidential Early Career Award in 2012 and a Technical Excellence Award from the American Indian Science and Engineering Society in 2007.

Networking and mentoring with purpose

Stan's outreach and engagement with tribal colleges and universities complement his work with tribes.

"Simply put, sovereignty is the right of the people to govern themselves; I believe that educating the next generation to become impactful community members is part of that right," Stan said. "By nurturing students and the younger generation, we ensure they become well-informed and valuable on-site assets within their respective tribes."

In his role with the NNSA's Minority Serving Institution Partnership Program, Stan visits tribal colleges and universities, talks with students and inspires them to pursue higher education and consider employment within NNSA's labs, sites and plants. The most rewarding part, he said, is when he receives a message from a student about being accepted into a graduate program or graduating from a prestigious program.

Stan mentors many tribal students, including Gordon North Piegan III, a Blackfeet Nation member and Sandia intern pursuing a Ph.D. at George Mason University. The Blackfeet Community College is deploying renewable and distributed energy systems, and Piegan is already contributing his technical expertise to his community.

Stan earned his bachelor's and master's degrees in electrical engineering from New Mexico State University in 1993 and 1995, respectively. In 2006, he became the first American Indian male to earn a doctorate in electrical and computer engineering from Virginia Tech University.

Stan advises students and future engineers to prioritize serving others rather than exploiting them.

"When you dedicate yourself to this mission, you discover true life and purpose," Stan said. "That's what I'm doing right now, and that's why I enjoy my job at Sandia so much. I'm leveraging my national and international influence to give back to tribal communities and tribal colleges and universities."

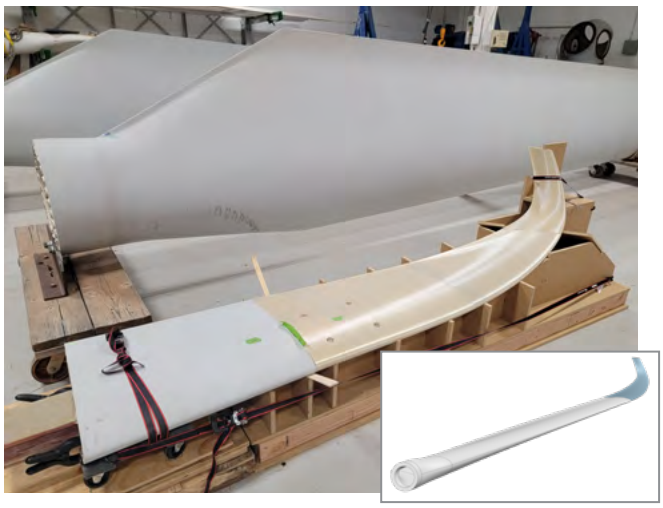
3D-printed part adds value to wind power

By **Kelly Sullivan**

Sandia's Wind Energy and Electrical Sciences researchers, in collaboration with Wetzel Wind Energy Services and Stratasys Direct Inc., have designed a new turbine blade tip that promises to make wind energy production more efficient.

The team recently completed the modeling and design phase of the Additively Manufactured System Integrated Tip project to develop a 3D-printed wind turbine blade tip that integrates several technologies and demonstrates a path to improved performance and reduced levelized cost of electricity, a measure of the cost of electricity generation over the lifetime of the wind turbine.

Funded by the U.S. Department of Energy's Advanced Materials and Manufacturing Technologies Office, the AMSIT project sought to address a number of current manufacturing inefficiencies, including manual composite-fiber-epoxy layup processes; poor quality control in manufacturing leading to blade defects and



TOP TIP — AMSIT tip and winglet mated to a 3D scan of the blade root (inset) and 3D-printed ground-based test article attached to a blade stub. Surface texturing and leading-edge protection are not shown.
Photo by Brent Houchens

failures in the field; erosion damage, especially at the tip; damage due to lightning strikes requiring extensive repairs or complete blade replacement; and expensive and complex shipping logistics due to the size of modern blades.

"3D printing offers a path to address all of these issues by integrating technologies," said Brent Houchens, AMSIT's principal investigator. "Here we considered a winglet to increase lift, surface texturing to reduce flow separation and features to improve leading-edge erosion protection and lightning protection."

"Although significant challenges remain in terms of the material properties and speed at which large parts can be 3D printed," Brent added, "strength and surface quality are advancing rapidly, and modular additively manufactured designs could reduce shipping and logistics issues, reducing emissions and securing supply chains. This is the first step to a future where blades can be manufactured in the field, on demand."

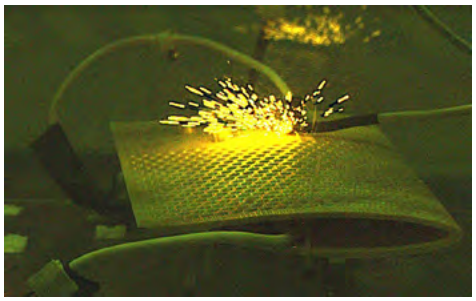
The additively manufactured design integration was demonstrated for a 200 kilowatt-scale turbine with 13-meter blades, while also examining the potential impacts for megawatt-scale machines. Approximately 15% of the blade tip was replaced with a 3D-printed design that improves aerodynamic performance via an upwind winglet and surface texturing, while simultaneously reducing repair costs through integrated leading-edge erosion and lightning protection. The team was able to explore highly complex geometries that would be challenging for traditional manufacturing processes but are straightforward for 3D printing. The potential for fast tip replacement — for example, after a catastrophic lightning strike — takes advantage of the modularity of the design.

Modeling results

Models predicted the change in levelized cost of electricity over a 25-year turbine lifetime, with performance improvements allowed only at low- and mid-wind speeds below 10 meters per second — the maximum rated power of the turbines were not changed so that AMSIT blades could be tested on existing machines. Even in this highly constrained design, techno-economic analysis demonstrated that when all four technologies are combined, levelized cost of electricity decreases significantly, between 3%-4% on average at wind speeds below 10 meters per second for a fixed print resolution, far offsetting the increased costs of 3D printing the tips.

Even more significant gains could be realized by increasing the rated power. At kilowatt scale, the winglet had the most impact by increasing the annual energy production at wind speeds considered. At megawatt scale (a megawatt is 1,000 kilowatts), performance increases and reduced maintenance and repair costs associated with erosion and lightning all contributed significantly to reduced levelized cost of electricity. As costs of 3D printing continue to decrease, the levelized cost of electricity from a design like AMSIT will continue to decrease.

WELL SUITED — Point cloud scans were made before and after cutting away the outer shells of the blades to allow new 3D printed tips (left) to be perfectly mated to the blade root (right). In the future, researchers hope to use the blade root to test different tips.
Photos by Brent Houchens



LIGHTNING THE LOAD — Simulating a functioning lightning protection system surviving an 8kV, 96 kA mock lightning strike.
Photo by Ray Martinez and Julia N. Tilles

Experiments and fieldwork

AMSIT researchers also conducted laboratory experiments to ensure the survivability of the 3D-printed materials against lightning strikes. Three lightning test scenarios included a strike directly at a simulated lightning protection system, a surface strike away from the lightning protection system and a strike with no lightning protection system.

Laser scans provided accurate blade geometries to mate the 3D prints to the existing blades. The outer shell of the blades were then cut away from the internal structure so that the new tips and winglets could be attached for ground-based structural tests and then field demonstration at the Sandia Scaled Wind Farm Technology site in Lubbock, Texas. These tests will help assess the progress of additive manufacturing toward the goal of 3D printing large sections of wind turbine blades and eventually even full blades.

"The AMSIT project demonstrates how integrating technologies through 3D printing could reduce the cost of wind energy by improving aerodynamic performance and reducing repair costs," Brent said. "Upon completion of the project the modified blade root and stub will be available for testing other novel tip designs."

To learn more about AMSIT, contact Brent C. Houchens.

How to cultivate connection at Sandia

By **Lea Blevins**

Some of Sandia's work takes place in sterile environments — literally. But mathematician Bert Debusschere says the process of working together doesn't have to be that way.

"Try simple things like, when you're in a meeting, start with asking how everybody's day is going," he said. "Tell me something that's going well in your life. Take that first five to 10 minutes, and just go around the room and talk about what's happening."

Fostering connections at Sandia

Bert took this tactic of making connections into his work at Sandia, pulling from his external work as a social justice trainer who focuses on building human interactions. Until recently, he was planning on retiring early from Sandia to focus on social justice work full-time. But when he brought elements of that work into Sandia, he realized what had been missing.

"It wasn't that I didn't like the work — I was missing the human connection," Bert said. "We have these sterile, cognitive work environments where we focus on meeting milestones for deliverables. And I had the insight that there's nothing keeping me from bringing that human element into my work at Sandia. It's really reconnected me to my love for the work I do at Sandia and also reconnected me to the people I work with."

MASTER CONNECTOR — When mathematician Bert Debusschere borrowed lessons from his social justice training and applied them to interactions at work, he initiated a culture where people look forward to connecting with colleagues.

Photo courtesy of Bert Debusschere

Taking the time to get to know people on a team will make the collaboration better, Bert believes. At the least, he suggests starting meetings with introductions whenever there is someone new — even better would be starting with a human-interest question to help form connections.

"At first, people were confused, asking, 'What is this guy doing? Where are we going with this?' But I found that after you do this for a couple months, people actually love it," he said. "It creates an environment where people show up to connect rather than because a meeting happened to be on their calendar."

Helping others feel like they belong

Since becoming a Sandian in 2001, Bert has been working to make others — and himself — feel a sense of belonging.

He originally joined Sandia as a foreign national and quickly discovered roadblocks to accessing seemingly simple things such as Information Release, the Sandia Daily News and even benefits information. Bert became part of the Division Diversity Council — now called the Sandia California Diversity Council — to represent foreign nationals and cofounded the Foreign National Networking Group.

"Once I became a U.S. citizen, the fact that I was born outside the United States did not seem to matter anymore," he said, recognizing that it's not always as easy for others. "As a white male from European descent, I fit right in here. Nobody ever questions what I am doing at Sandia. I've never had to argue for belonging."

Bert stepped down from the Foreign National Networking Group once he became a U.S. citizen, but he is acutely aware that people of other backgrounds may not feel the same level of belonging. He's now part of an Integrated Security Solutions division Integrator Team focusing on identifying opportunities to drive belonging and connection.

CONNECTING WITH COWORKERS — Bert Debusschere, center, with Jasmine King-Bush, left, and Ken Patel at the Vision 2020 Diversity and Inclusion Strategic Planning Event.

Photo courtesy of Bert Debusschere

Forming and leading diverse teams

Working with Kelly Nykodym, the human resources business partner to the Sandia California Diversity Council, and Cindy Vu, a human resources specialist for Integrated Security Solutions, Bert led workshops this spring and summer on forming diverse project teams and leading connected teams. Anyone who missed them but is interested in these topics can contact Kelly Nykodym.

"I hope the Labs continues to invest in teaching people how to be good meeting facilitators, both in virtual and hybrid spaces, and figure out how we can be a truly connected workforce," Bert said, adding that Sandia has trained facilitators on staff who can be brought in. "Let them design the meeting so everyone gets to say what they need to be saying. We have resources at Sandia — we don't have to do this on our own."

A place for connection, belonging

This is the second in a series of Sandians sharing their personal stories as part of the Labs' People and Culture strategy and the Integrated Security Solutions division's focus on belonging, connection and contribution — all aimed at making Sandia a great place to work.

The first profile in the series featured Brian Duong, who shared his own story of inclusion among colleagues at Sandia.

Graphic by Krissy Galbraith

Mileposts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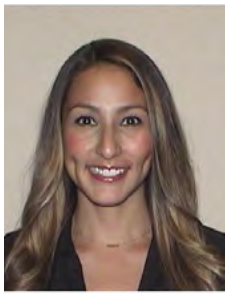
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Achieving the impossible

Teaching NM high schoolers quantum science

By **Kim Vallez Quintana**

"They said you can't teach quantum science at the high school level; we've proven them wrong," said Megan Ivory with a huge grin on the last day of QCaMP 2024.

Megan, a Sandia physicist, co-founded the camp with Sandia business development specialist Jake Douglass in 2022 aiming to introduce the complex and often mysterious science to young people. On this day it was clear they succeeded.

"We learned everything that is foundational to quantum; from quantum bits and gates to classical bits and gates so that we can understand quantum bits and gates," said Anirudh Nanda, a camp participant and student at Albuquerque Institute of Math and Science. Nanda was one of 15 students who attended the camp on the University of New Mexico campus this year.

On closing day, all stood proudly before their families, instructors and community members to present their final projects and demonstrate what they had learned over the previous four weeks.

QUANTUM THROUGH LIGHT — On the final day of QCaMP, Ines Montano of SparCQS, shows an example of polarization, a quantum phenomenon, to students William McGlumphy, Carter Barba and Keith Harrison. **Photo by Craig Fritz**

Nanda and teammates Kiondra Jim of Farmington and Taylor Billiman of Gallup explained how quantum could speed up pharmaceutical development.

"Modern medication development is a very time-consuming process that takes decades of research," Jim said. "One solution is to speed up the process with quantum computers to help chemists understand how molecules react and bond."

Student projects also focused on using quantum key distribution to keep digital information safe and using quantum sensing to create better prosthetic limbs. "Through this we can help veterans who have had an arm or leg amputated by creating prosthetic limbs that feel like you didn't lose anything," Carter Barba, a junior at Albuquerque High School, said about his project.

The students say while the projects and experiments were the best part, the camp opened a whole new world for them. "Quantum is not something I had really thought a lot about, but it is something that I could do in the future," Eldorado High School student William McGlumphy said. "We learned just how much quantum is going to affect our futures. It really is going to be a huge technological thing, and best of all we got to shoot lasers."

For some students, the camp was eye opening in a different way, including Valley High School Junior Harrison Jolly. "I learned that there are things that make my brain hurt and I don't understand," he said. But Jolly said that won't discourage him from going into computer science: "There are going to be a lot of applications for quantum in the future and knowing how to use a quantum computer is key."

Jake hopes the students know that those futures can be right here at home. "We are doing this to work with New Mexico students, to keep them here, to give them opportunities."

For Jake, that is especially important. He is what Megan likes to call certified "New Mexico True." Born and raised in Roswell, Jake earned degrees from New Mexico Tech and Highlands University and now has a successful career at Sandia.

"We want these kids to know this is not just a stand-alone camp. We are working with partners around the state to build pathways for students to get into quantum at CNM, UNM, New Mexico Tech or NMSU," Jake said. "If students leave, we want to make sure they can come back to awesome jobs, which we are also working on. New Mexico can't often say it's a world leader in something but in the case of quantum, we can."

LASER LEARNING — Joey Benavides, left, and Anirudh Nanda work with lasers to learn principles of quantum science while at QCaMP, held at UNM. **Photo by Craig Fritz**

TEACHING IS A PASSION — Joey Benavidez, left, and Anirudh Nanda get help from instructor Joan Arrow while working with lasers to learn the principles of quantum science while at QCaMP. Nearly a dozen instructors helped at this year's event at UNM. **Photo by Craig Fritz**

The creation of QCaMP

QCaMP, which stands for Quantum Computing, Mathematics and Physics, became one of the first programs of its type in the country when it was created in 2022 by Megan Ivory and Jake Douglass. It started as a virtual-only camp and has grown into an in-person four-week camp for students and three-day camp for teachers. In addition to the students at UNM this year, three New Mexico students were also able to attend remotely in Santa Fe and another 24 students attended QCaMP in California thanks to partners at Lawrence Berkeley National Laboratory and others. To date the camp has taught 143 teachers and 148 students. Thanks to grant funding, both teachers and students receive a stipend to ensure they don't have to choose between working a summer job and learning about science. QCaMP is made possible in New Mexico through the support of Sandia, Los Alamos National Laboratory, UNM and the Computer Science Alliance.