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National Security Programs host art show Page 8

Silicon nose: Small sensor "smells" incipient seizures

Device detects seizure gases, providing advance warning

By **Mollie Rappe**

In people with epilepsy, seizure-alert dogs can smell small changes in body chemistry and warn of an impending seizure an hour or more before it occurs. Inspired by this feat of nature, a team of researchers has sniffed out a way to replicate the ability with technology.

Sandia and research partner Know Biological Inc. have developed a miniaturized sensor system that can detect the specific gases released from the skin of people with epilepsy before a seizure.

The Sandia-designed device was able to sense the key gases from gauze swiped on a patient's skin 22 minutes before the onset of a seizure, said Gary Arnold, CEO and founder of Know Biological.

For people who have epilepsy, knowing they will have a seizure in advance gives time to take medication that can halt most seizures

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PUBLIC-PRIVATE PARTNERSHIP — Gary Arnold, CEO and founder of Know Biological, holds part of a miniaturized sensor system designed by Sandia biomedical engineers. The sensor can detect gases released from the skin of people with epilepsy before a seizure. **Photo by Craig Fritz**

INTERACTIVE MODELING — Virtual technologies manager Justin Serrano interacts with models using Sandia's digital engineering visualization capabilities during a poster session at the second annual Digital Engineering Workshop. **Photo by Sofie Schunk**

Improving mission delivery starts with digital engineering

By **Kenny Vigil**

The second annual Digital Engineering Workshop at Sandia is being hailed as a success. More than 350 people, including attendees from other national laboratories, participated both in person and virtually. Digital engineering is an integrated digital approach that applies authoritative data and models as a continuum across disciplines.

Rita Gonzales, associate Labs director for Nuclear Deterrence Modernization and Future Systems, delivered the keynote speech on

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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 Lab News editor Katherine Beherec at kgbeher@sandia.gov.

NNSA principal deputy administrator visits Labs

MESA TOUR — Ed Meier, associate director for National Security Programs White House Office of Management and Budget, front second from left, and NNSA Principal Deputy Administrator Frank Rose, right, visited Sandia New Mexico on June 5. They were welcomed by Labs Director James Peery, back left. The visit included a tour of the Microsystems Engineering, Science and Applications facility to learn more about the Labs' innovative solutions to complex problems in support of the national security mission.

Photo by Craig Fritz

Digital engineering

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the opening day. She emphasized that digital engineering will transform how Sandia performs its work, enabling the Labs to be more efficient and effective for the benefit of the nation. "Digital engineering will be the key to transforming production. This transformation is a journey that requires time, effort, strong partnerships and commitment," Rita said. One of the primary goals of digital engineering is to help members of the workforce become better designers.

The workshop took place May 9-11 at the Steve Schiff Auditorium. Other keynote speakers included Jennifer Gaudioso, computing research director at Sandia, and Christopher Ritter, digital engineering director at Idaho National Laboratory.

A common theme that emerged during the keynotes and throughout the workshop was the significance of collaboration across the nuclear security enterprise.

"The workshop highlighted the desire for cross-site collaboration in digital engineering transformation efforts, with the goal of sharing technologies, processes and lessons learned," said Michael Mitchell, who is involved in leading the implementation of digital engineering at Sandia. "Digital engineering has the potential to significantly improve mission delivery across NNSA."

NNSA, NASA, Raytheon Technologies Corp. and other key partners also participated in the workshop, which featured more than 30 presentations and a poster session. Sandia is already looking forward to hosting the third annual Digital Engineering Workshop next year.

Pride flag honors LGBTQ+ staff

FLY THE RAINBOW FLAG — Nuclear engineer Matt Allen hands off the pride flag as it is passed down a line of participants before it is raised outside the administrative office at Sandia New Mexico. On June 1, Sandia raised the pride flag to kick off Pride Month and celebrate the LGBTQ+ staff members who help fulfill the Labs mission. **Photo by Craig Fritz**

Sensing a seizure

CONTINUED FROM PAGE 1

or, at the very least, to get somewhere safe and private.

"A friend of mine has epilepsy," Arnold said. "He told me that having a seizure is horrible but that it's not the worst part of epilepsy. The worst part of epilepsy is never knowing when you're going to have a seizure. The psychological impact of that uncertainty is overwhelming."

How does the nose know?

Arnold and academic collaborators wanted to know how seizure-alert dogs knew when a seizure was imminent. They identified the presence of several key volatile organic compounds, known as VOCs, for the gases responsible for everything from the smell of fresh-cut grass to the odor of drying nail polish. They discovered that seizure-alert dogs know when a seizure is imminent because they smell the change in body chemistry.

"We were able to identify a bouquet of eight VOCs that were unique to seizures," Arnold added. "Of those, three VOCs were considered principal, appearing in every sample taken from someone having a seizure. These VOCs start building in concentration prior to seizure onset."

Arnold reached out to Sandia after hearing about work developing a **handheld chemical detector** for the military. Sandia's work developing a miniaturized gas detection system began **more than 25 years ago** as part of a large internal research investment.

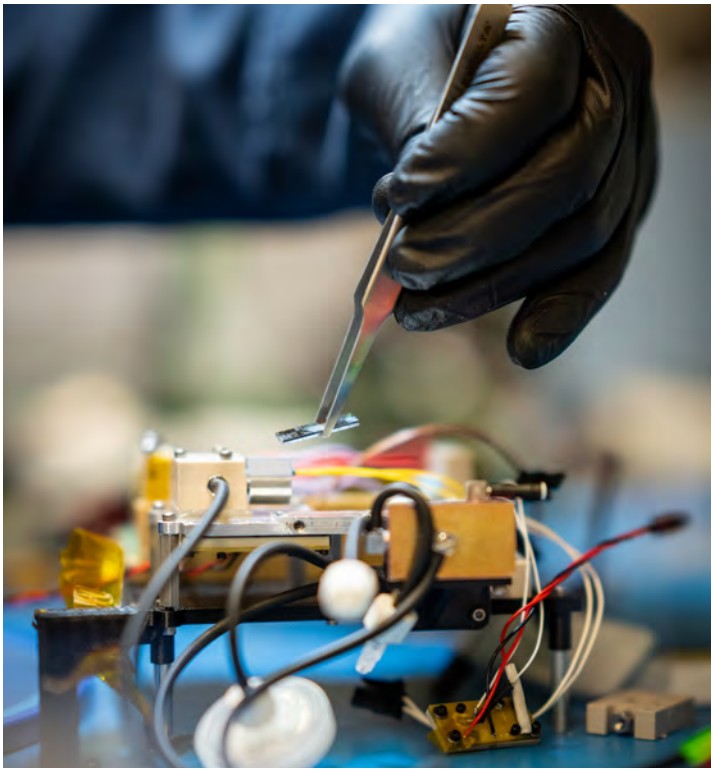
Making a silicon "nose"

Arnold and Sandia biomedical engineer Philip Miller have been working on adapting the miniaturized system to detect the gases Arnold's collaborators had previously identified.

"We used a three-part system to do the analysis," Philip said. "We split the analysis into multiple stages to do the collection, separation and identification of VOCs. Two of the components are made in Sandia's **Microsystems Engineering, Science and Applications** silicon fabrication complex."

The first Sandia-made microdevice serves as a "sponge" to soak up gases. The sponge or **pre-concentrator**, a silicon-based device slightly smaller than the inner loop of a mini-paper clip, collects VOCs from a bit of gauze that had been on a patient's skin and holds onto them, letting the much smaller gases that make up air, such as oxygen, nitrogen and argon, flow through. After collecting gases from the gauze sample, the pre-concentrator was rapidly heated. The heat effectively "wrings" out the sponge, sending the VOCs into the next stage of the sensor. The pre-concentrator allows the device to detect even minuscule amounts of the gases of interest, Philip added.

SEIZURE WARNING SYSTEM — **Watch a video** about the miniaturized sensor system and how it can mimic seizure-alert dogs in providing warnings of impending seizures. **Video by Ruth Frank**



SMALL SENSOR SMELLS SEIZURES — A Sandia researcher works on a miniaturized sensor system able to detect specific gases warning of an impending seizure. **Photo by Craig Fritz**

The next stage, the separation stage, uses two miniaturized gas chromatography columns to separate the gases released from the pre-concentrator. Each of the columns is a tiny serpentine channel etched into a 1.2-by-1.2-inch square of silicon, Philip said. The two columns separate the gases based on two different chemical properties. Just like a doctor's office separating out patients' files by last name and then birthdate, using two different columns reduces the chances of a case of mistaken identity.

The third stage, the identification stage, uses a Sandia-made **miniature ion-mobility spectrometer** to detect the gases as they come out of the second column. This detector is sensitive enough to detect even tiny amounts of gases, such as the biological VOCs in this project or trace quantities of explosives, Philip said. For the prototype seizure detection system, it takes five minutes to analyze a sample from start to finish.

Philip's team also designed the microcontrol board that controls the various components in the silicon-based seizure gas detection sensor.

From the benchtop to the wrist

So far, Sandia and Know Biological have received four joint patents and have two other patent applications under review, Arnold and Philip said. Philip said the company has also licensed several Sandia technologies to test in this sensor.

The next step is to tweak the prototype sensor to sniff gases directly from someone's skin, rather than from a bit of gauze that had been on their skin, Philip said. He doesn't expect this to pose much challenge, but it is an important step before the system can be refined into a watch-like wearable sensor with the ability to collect samples throughout the day.

Then, the sensors can leave the lab and go home with people with epilepsy. Arnold expects to enroll patients in beta testing soon, with hopes of having the sensor on the general market by the end of 2024.

"To me, this test is the period at the end of the first full chapter on the microChemlab story," Philip added. "Greg Frye-Mason envisioned this more than 25 years ago, and we're now at a point where the system can be used as a medical device that could significantly improve the health and well-being of an individual. That's really cool. The next chapter is getting it out of the lab and into the hands of healthcare providers and patients."

Recent Patents

January–March 2023

Note: Patents listed here include the names of active Sandians only; former Sandians and non-Sandia inventors are not included.
Following the listing for each patent is a patent number, searchable at the U.S. Patent and Trademark Office website (uspto.gov).

- **Yuan-Yu Jau and Peter Schwindt:** Optically pumped gradient magnetometer. Patent #11543474
- **Martha Spoerke Gross, Stephen Percival, Mark A. Rodriguez, Leo J. Small and Eric David Spoerke:** Sodium electrochemical interfaces with nasicon-type ceramics. Patent #11545723
- **Christopher Todd DeRose, Michael Gehl and Jongmin Lee:** Compact laser source with frequency modulators generating multiple lines. Patent #11545815
- **Cy Fujimoto:** Poly(phenylene) with high ion selectivity for use in anion exchange membranes. Patent #11549011
- **Clifford K. Ho and Hendrik F. Laubscher:** Radial particle-based terrestrial thermocline for high temperature thermal storage. Patent #11549761
- **Christian Lew Arrington, Jonathan Joseph Coleman, Amber Lynn Dagel, Andrew Eugene Hollowell, Carlos Perez, Jamin Ryan Pillars and Christopher St. John:** Enhanced microfabrication using electrochemical techniques. Patent #11549903
- **Christopher Todd DeRose, Michael Gehl, Raymond A. Haltli and Hayden James Evans McGuinness:** Miniaturized vacuum package and methods of making same. Patent #11551921
- **Michael Hibbs, Jeffrey S. Nelson, Paul J. Resnick and Carlos Anthony Sanchez:** Moldable photovoltaic solar cell module. Patent #11552211
- **Darren W. Branch, Philip Rocco Miller and David R. Wheeler:** Microfluidic package and method of making the same. Patent #11554369
- **Clifford K. Ho:** Systems and methods for shielding falling particles within a solar thermal falling particle receiver. Patent #11555634
- **Antonio Gonzales and Cara Patricia Monical:** Homography generation for image registration in inlier-poor domains. Patent #11557019
- **Matthew W. Moorman and Joshua J. Whiting:** Health monitoring device. Patent #11559246
- **Gina Marie Geiselman, John Michael Gladden and Di Liu:** Methods of producing lipid-derived compounds and host cells thereof. Patent #11560576
- **Travis Ladell Bauer, Richard V. Field Jr., Tu-Thach Quach and Christina Ting:** Efficient generalized boundary detection. Patent #11563446
- **Brooke Nicole Harmon, Oscar Negrete and Joseph S. Schoeniger:** Small molecule inhibitors for treatment of alpha viruses. Patent #11564919
- **Erica Marie Redline, LaRico Juan Treadwell and Andrew Vackel:** Method for attaching nanomaterials comprising hexagonal lattices to polymer surfaces. Patent #11566088
- **Stephen Buerger and Jiann-Cherng Su:** Modular anti-rotation drilling systems and methods. Patent #11566497
- **Andrew Jay Leenheer:** Piezoelectric deformable photonic devices. Patent #11569431
- **Susan Elizabeth Henkelis, Tina M. Nenhoff, Stephen Percival, Mara Elizabeth Schindelholz and Leo J. Small:** Low power sensor for nox detection. Patent #11573217
- **Erica Marie Redline:** Fluid-infused elastomers. Patent #11584841
- **Timothy Briggs, Brian K. Holliday and Kyle James LeBlanc:** Wire rivet. Patent #11585363
- **Yuan-Yu Jau:** Low-frequency atomic electrometry. Patent #11585841
- **John Joseph Borchardt, Shane Keawe Curtis, Chad Hettler and Tyler Cruz LaPointe:** RF signature detection for waveguide deformation. Patent #11592405
- **Karla Rosa Reyes:** Thermal measurement apparatus and methods for anisotropic thermal materials. Patent #11592408
- **Stephen Neidigk and Thomas M. Rice:** Magnetic self-mating fiber optic connector and fiber optic switch sensor. Patent #11592625
- **Ehren Baca and Cy Fujimoto:** Ion-selective membrane for redox flow batteries. Patent #11600838
- **Jonathan Anton Bock, Harlan James Brown-Shaklee, Leo J. Small and Erik David Spoerke:** Solution-assisted densification of nasicon ceramics. Patent #11600856
- **Michael Edward Ferdinand and David Michael Siler:** Vibration isolation for centrifuge testbeds. Patent #11612899

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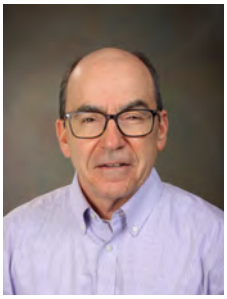

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Recent Retirees

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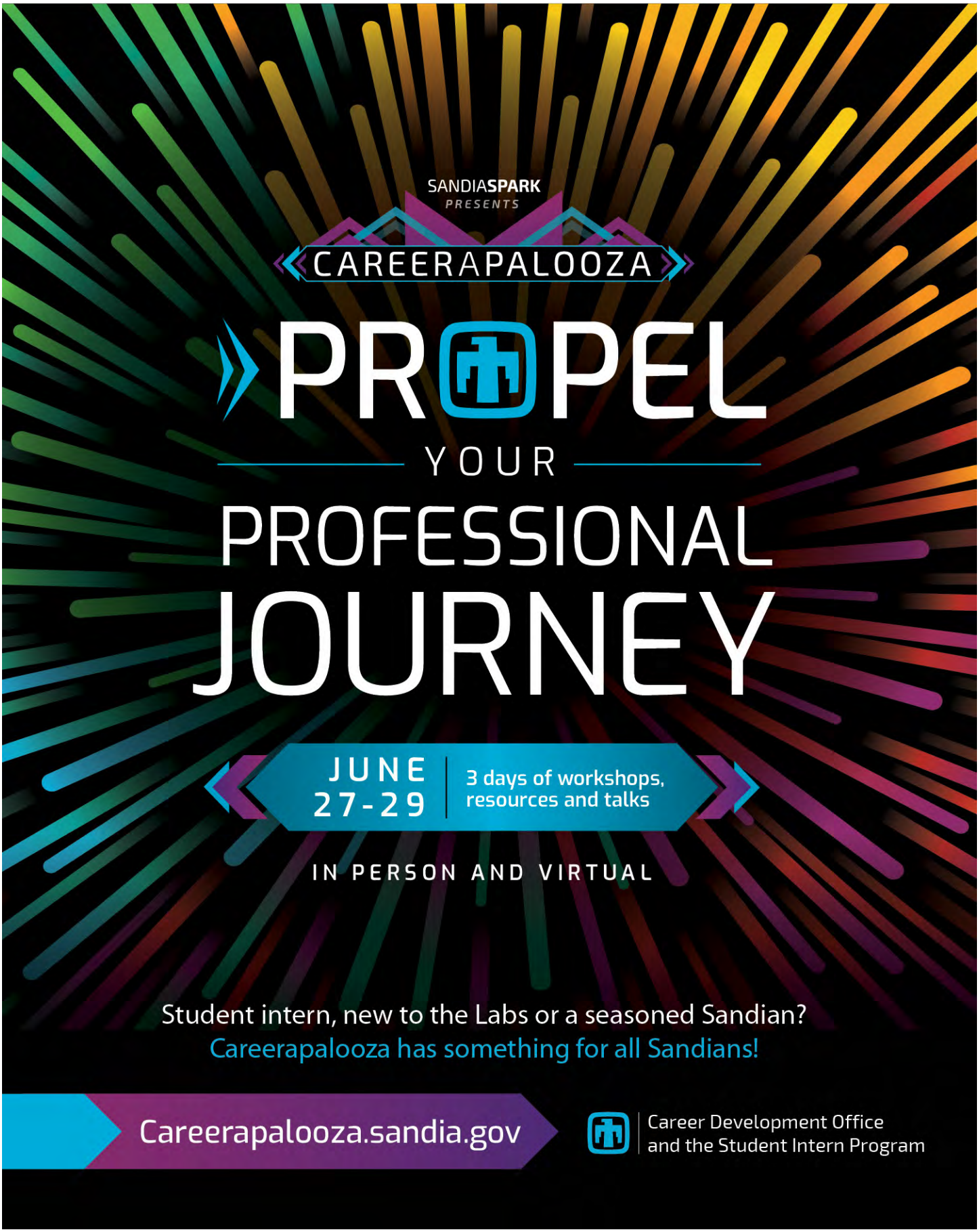
Safe driver represents Labs at trucking championship

TRUCKING TITLE — Aaron Trujillo, Transportation and Receiving Heavy team member, fourth from left, was awarded second place in the Five Axel Class in the New Mexico Trucking & Safety Council 2023 Truck Driving Championship on May 20. He cited more than 10 years of experience for his success.

"People can't get in the gates and see what we're doing daily," Aaron said. "This win can put Sandia on the map in the trucking industry."

Aaron participated in the competition for the first time in 2022 and plans to return next year to further represent truck driving at Sandia. Sandians Dominic Torres, Luis Vergara and Bernadette Bazen also participated in the competition. **Photo by Liz Carson**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National Security Programs celebrate team members' artistic talents

Photo and story by **Andrea Mackay**

National Security Programs hosted its first-ever art show to celebrate the artistic talents of team members across the organization. An opening reception was held on May 18, with Deborah Frincke, associate Labs director of National Security Programs, and division center directors in attendance. The reception included a coffee bar, a live performance by Tammy Brown and Mellisa Heller from Sandia Singers and an in-person showing of the artwork.

"This warm-hearted event was a great opportunity to celebrate the artistic talent of our workforce, stepping away from our daily work and enjoying the creativity of our colleagues outside their day jobs. We clearly need to make this a new annual tradition," Deborah said.

The art show, organized by Program Communications Specialist Auri Atencio, showcased 22 artists and 56 works of art, with mediums ranging from crocheted dolls to jewelry, paintings and stained glass.

"The art show was a great way to get a glimpse at our coworkers' lives outside of work. I was honored to be an artist in our first showcase," mechanical engineer Stephanie Bouchey said.

The art show was so well received that the division plans to make it an annual event.

COFFEE AND ART — From left, Director Reno Sanchez, Director Dennis Helmich, National Security Programs Associate Labs Director Deborah Frincke and Director Kate Helean offer coffee and conversation to team members.

COLORFUL GLASS — The art show included stained glass pieces by systems engineer Mark Dietrich.

GLAZED AND FIRED — Information technology solutions architect Harry Kuykendall displayed his ceramic pieces at the art show.

HIDDEN TALENTS — The National Security Programs art show featured prints by aeronautical engineer Daniel Whitten.

CROCHET CREATIONS — The event showcased work by administrative support professional Autumn Flanery.