



Sandia  
National  
Laboratories



# TECHNOLOGY Partnerships

ANNUAL REPORT  
FY 2021

Overcoming Hydrogen  
Energy Challenges



“Sandia is a critical hub of innovation that continues to power commercialization through its longstanding practice of driving economic and national security impact from laboratory technologies. This report exemplifies the power of partnerships in our mission-driven work and I look forward to yet another year of enterprising leadership.”

— Dr. Vanessa Z. Chan

*Chief Commercialization Officer  
Director, Office of Technology Transitions  
U.S. Department of Energy (DOE)*



“Our use-inspired research, development, demonstration, and deployment (RDD&D) endeavors have expanded the commercial impact of research investments made by Sandia. The select technology transitions highlighted in this report are both impressive and reflect an ongoing dedication by DOE/ NNSA and Sandia to foster economic growth and security for our nation.”

— Dan Sanchez

*DOE Technology Partnerships Manager  
National Nuclear Security Administration (NNSA)  
Sandia Field Office*

“Sandia develops creative solutions to the most complex national security challenges. Our Partnerships Program ensures that many of these trailblazing technologies are brought to the marketplace where millions of Americans can benefit. Sandia’s innovations in the hands of our partners in industry, academia and government strengthen the country, promote economic competitiveness, and improve the quality of life. We are committed to technology transfer and to the partnerships that help it thrive.”

— James S. Peery

*Laboratories Director  
Sandia National Laboratories*



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About the cover:

Visitors tour BayoTech’s Center of Excellence and learn about the unique technology powering the H2-1000 hydrogen steam methane reformer.

See story on page 20.



"In the RDD&D process, partnerships with industry, academia, and other national laboratories are not just between people: facilities also help move technology forward. Sandia's specialized facilities are frequently utilized as a vital resource in technology maturation and transfer. Giving partners access to unique research resources and capabilities gives them a strategic advantage, and moves U.S. technology deployment forward."

— Susan Seestrom

*Associate Laboratories Director & Chief Research Officer  
Advanced Science and Technology  
Sandia National Laboratories*



"Our broad university partnerships are absolutely critical to our foundational and applied research and development efforts. By partnering with our academic colleagues, we multiply Sandia's research advances and enable deployment of capabilities while also training the next generation of engineers and scientists to tackle challenges of national importance."

— Basil Hassan

*Director and Deputy Chief Research Officer  
Chief Research Office  
Sandia National Laboratories*



"Sandia takes part in both DOE and regional technology transfer programs. These programs support RDD&D for Sandia and our partners. Last year, 20 years of technical assistance to local businesses was celebrated by one Sandia program, while a new program was begun to fill an assistance gap for local companies moving licensed New Mexico national laboratory technology towards deployment."

— Mary Monson

*Senior Manager  
Technology Partnerships & Business Development  
Sandia National Laboratories*



## Partnerships and RDD&D Move Technology Innovations to Market

The DOE and Sandia National Laboratories place an emphasis on supporting every stage of technology innovation, including research, development, demonstration, and deployment (RDD&D). Each step of RDD&D is necessary in order to move lab-developed technologies to the marketplace, where they can make a difference for the nation's economy and well-being.

Partnerships between Sandia, industry, universities, national laboratories, and government agencies are essential for RDD&D of clean energy and other technologies that activate job creation. These partnerships reduce technical and economic risk on the path to commercialization, helping to enable widespread implementation of technologies, materials, and processes that will have a high impact.

Here are just a few of the Sandia partnerships highlighted in this annual report. They are advancing through RDD&D by:

- Overcoming production and transportation challenges for hydrogen energy with distributed production
- Moving flexible solar power to space with assistance from the TRGR Technology Readiness Initiative
- Speeding up metamaterial design through the use of inverse design methods, making theoretical materials a reality
- Designing stronger, safer mechanical parts by studying ceramic materials at the nanoscale
- Demonstrating a path forward for incorporation of DC/AC microgrids on the current electrical system

The implementation of transformational technologies requires increased public and private investment at all stages, and partnerships help accelerate the process. Through partnerships, Sandia is fulfilling its mission requirements while helping to maintain U.S. leadership in science, technology, and clean energy innovation.

## LDRD Program Essential to Mission Capabilities

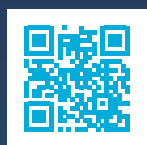
Research conducted within the Laboratory Directed Research and Development (LDRD) program is essential to maintaining the vitality of Sandia's mission-critical science, technology, and engineering capabilities. The LDRD program has benefited Sandia's work in all of its national security mission areas, including nuclear security, energy security, and global security.

The Labs and its strategic partners gain from collaborative research results. Many technological breakthroughs originating from, or improved through the LDRD program, are later transferred to industry, commercialized under licensing agreements, and brought to market for the U.S. public good.



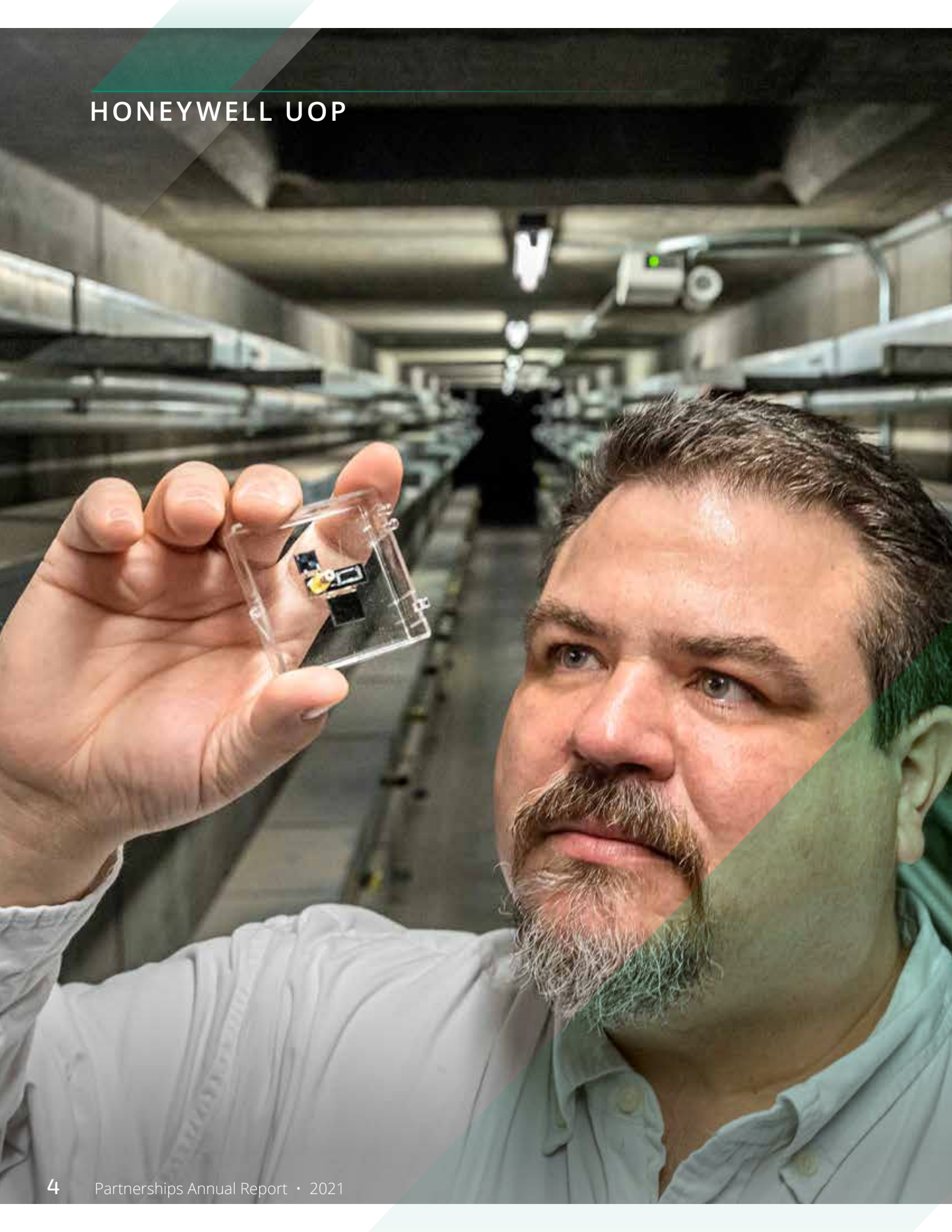
LABORATORY DIRECTED  
RESEARCH & DEVELOPMENT

*Look for the LDRD logo  
in this report to discover  
which technologies grew  
out of the LDRD program.*



To learn more, visit  
[www.sandia.gov/ldr](http://www.sandia.gov/ldr)

# HONEYWELL UOP



“Partnering with the micro-GC experts and resources at Sandia offers UOP an accelerated pathway to help our customers in the biofuels and petrochemical industries to optimize process technology by monitoring more complex feed, intermediate, and product streams through invention and commercialization of affordable, miniaturized multidimensional gas chromatography sensors.”

— Michael McCall

*Principal R&D Scientist  
Honeywell UOP*

■ Sandia Analytical Chemist Joshua Whiting examines a gas sensor that could be used in a small process analyzer to handle complex samples.

## Small Gas Chromatograph Reduces Time and Costs for Industry

### CHALLENGE

In the petrochemical industry, analytical processes are typically monitored by large, expensive instrumentation located remotely either in a lab or climate-controlled shed. It can be an hour or more from the time a sample is collected until actionable information is available to plant operators. That’s why there is an increased effort to place lower cost instrumentation directly on the pipe in the plant, but these instruments lack the resolution to analyze complex samples. Customers are seeking a compact solution that can quickly provide complete compositional data without the high capital expense of instrumentation sheds.

### COLLABORATION

[Honeywell UOP](#) is an industry leader in the development and deployment of technology that improves the efficiency, productivity, and profitability of the petrochemical and bulk chemical manufacturing industries. UOP processes are key to the production of fuels and natural gas; as well as biodegradable detergents, plastic resins, films, and fibers used in commercial goods, packaging, and fabrics.

Sandia National Laboratories has decades of experience developing novel sensor platforms as part of its national security mission. A small, microfabricated, multidimensional gas chromatograph (GC) was developed by Sandia for chemical weapons detection, and now this technology is finding new applications for industry.

### SOLUTION

GC is the primary analytical method used in process analysis across the petrochemical and manufacturing markets. One of the sensors being developed under the UOP-Sandia partnership uses Sandia’s small GCxGC technology.

Sandia’s miniaturized, multidimensional GC technology enables a significant reduction in the instrument footprint, which enables moving the sensor closer to the sample, mounting it directly on the pipe. This eliminates costly instrument sheds, lowers installation costs, decreases the time to actionable information, and reduces wasted product. In addition, this first of its kind process analyzer will allow the petrochemical industry to analyze more complex samples. As a wholly owned subsidiary of Honeywell, UOP can work with other Honeywell business units to manufacture and commercialize the sensor solution.

### IMPACT

Transferring the GC sensor system to Honeywell UOP will introduce a disruptive technology into the market for feedback, control, and optimization of oil, gas, and renewable technologies, resulting in improved efficiencies, purity, profitability and decreased waste. As industry transitions to biofuels, this technology can be used with new green fuels created from sustainable sources.

The multidimensional GC-based sensor platform being developed as part of this partnership also has the potential to significantly impact multiple industries beyond the petrochemical industry, such as pharmaceuticals, food safety, biomass, and flavors and fragrances.

**PARTNERSHIP TYPE:** *Umbrella Cooperative Research and Development Agreement (CRADA)*

**GOAL:** *Developing a microfabricated, multidimensional gas chromatograph that can improve efficiency for process analysis sensor systems*



KNOW BIOLOGICAL





“I can’t say enough about Sandia’s scientists and technology. The fact that they had already miniaturized the exact components we needed took us a long way very quickly. I know there are a lot more good things ahead of us with this partnership.”

— Gary Arnold

CEO  
Know Biological, Inc.

■ Sandia Researchers Joshua Whiting, Matthew Moorman, and Philip Miller testing a circuit board that controls the components for VOC analysis.

## Portable Detector Alerts People of Seizures Before They Happen

### CHALLENGE

For people living with epilepsy, having a seizure can be a horrible experience, but even worse—not knowing when a seizure might happen. Depending on when and where it occurs, a seizure can be dangerous.

As CEO of Canine Assistants, Gary Arnold had been involved with teaching seizure response dogs. It soon became obvious the dogs were not just responding to seizures, but predicting them. How did they do it? After eliminating other possibilities, Arnold and his collaborators discovered it was because the dogs, with their sensitive sense of smell, could detect particular volatile organic compounds (VOCs) coming from their human partners. With 3.7 million people having epilepsy in the U.S., training enough dogs seemed impossible. Arnold thought a portable sensor system might be the answer.

### COLLABORATION

Arnold knew he needed help realizing his dream. He started researching sensor systems, and saw an article about the work Sandia National Laboratories had done to miniaturize versions of benchtop equipment, like gas chromatographs (GC) and an ion mobility spectrometer (IMS). These technologies were originally conceived of to solve national security mission challenges such as detecting chemical warfare agents.

Arnold talked to Sandia Researcher Matthew Moorman. With several VOCs indicative of seizures [Know Biological](#) had already identified through prior research with a university, Sandia and the company began collaborating on creating a portable seizure detection system.

### SOLUTION

A system is now being developed using Sandia licensed technology and work being done jointly by Know and Sandia under a CRADA. The first prototype is portable, under 5 lb., with plans to make future systems smaller, and ultimately a very small wearable device.

The noninvasive detector is a three-stage analysis system using Sandia’s miniaturized pre-concentrator (PC), GC, and IMS. It will collect biomarker VOCs from the patient, separate the collected biomarkers from environmental interferences, and detect the individual biomarkers of interest. The complete system will produce high-reliability results that patients can trust.

### IMPACT

Epilepsy affects 65 million people worldwide. For the 30% of people living with epilepsy whose seizures are not well controlled by medication or surgery, the new wearable system can be a game changer, immediately improving their quality of life.

Sandia and Know have already filed for four joint patents based on the work they’re doing; two have already been awarded. This is in addition to the two Sandia patents Know is licensing. There are also multiple future applications as a multitude of medical conditions produce VOCs, meaning wearable detection devices can be useful for millions of people.

**PARTNERSHIP TYPE:** Licenses and umbrella Cooperative Research and Development Agreement (CRADA)


**GOAL:** Inventing a wearable detector that provides seizure alerts for people with epilepsy, improving their quality of life

# LIFELOC TECHNOLOGIES



“As marijuana legalization spreads, the need for rapid and reliable testing methods has increased. This partnership is a great way to leverage the tremendous technical resources of Sandia with Lifeloc’s history of manufacturing devices that make the roads safer.”

— **Dr. Wayne Willkomm**  
CEO  
*Lifeloc Technologies, Inc.*

 Lifeloc Engineer Chris Novak evaluating a new prototype SpinDx assay.

## New Product Makes Testing for Drug Intoxication Easier

### CHALLENGE

With the legalization of marijuana in more states, its use is becoming more prevalent. But unlike testing for alcohol intoxication, which is now easy to do with a breathalyzer, measuring impairment caused by marijuana is more complicated. Impairment from marijuana occurs at a much lower concentration of delta-9-THC (the primary psychoactive agent of marijuana) compared to alcohol. Also, THC is a large molecule that is not very volatile, so there’s very little in the breath. In addition, the THC has to be separated from a number of other non-psychoactive compounds.

These complications mean there has been no accurate, rapid way to test for marijuana intoxication of drivers on the road or employees in the workplace. Current testing methods can be expensive and slow, with results being returned in weeks rather than minutes.

### COLLABORATION

[Lifeloc Technologies](#) is a world leader in alcohol breath detection with years of experience in producing robust, portable electronic testing devices that are easy to use. When the company wanted to tackle the pressing problem of testing for marijuana and other drugs, they evaluated a number of technologies. Lifeloc decided that SpinDx™, invented at Sandia National Laboratories, would be the most practical method.

Sandia originally developed SpinDx, a “lab-on-a-disk”, to detect biological threats as part of its national security mission. Now SpinDx is being utilized in a variety of applications. Working with Lifeloc under a CRADA, Sandia is transferring the licensed technology and expertise needed so the company can develop a line of drug testing products.

### SOLUTION

SpinDx uses a centrifugal disk with microfluidic flow paths that allows multiple tests to be carried out on a single, small sample. It can support testing of different sample types and screening for a variety of drugs of abuse.

Using SpinDx technology, Lifeloc is developing a rapid test device for measuring the THC level in saliva. This is planned to be the first in a line of products based on the SpinDx platform that will run tests on breath or other sample types.

### IMPACT

For Lifeloc, entering this new market area of detecting drug-impaired drivers and employees will greatly expand its product portfolio, enhancing the company’s decades-long focus on alcohol testing.

For law enforcement and employers, the new products will give them a way to test for marijuana and other drug intoxication as easily as they can now test for alcohol. That means these tests could contribute to lowering driving fatalities and workplace accidents worldwide.

**PARTNERSHIP TYPE:** License and Cooperative Research and Development Agreement (CRADA)

**GOAL:** Increasing safety by creating a rapid and accurate test platform for measuring drug intoxication in drivers or employees



# PURPLE CITY LABS





“LAMP has been around for two decades and there have been various approaches to report the products of this reaction. QUASR, from Sandia, stands apart in its brightness, ability to facilitate the detection of two targets at once, and extra layer of protection against false positives.”

— Ali Bektaş

Founder and CEO  
Purple City Labs, Inc.

■ Purple City CEO Ali Bektaş and Lab Director Kjel Mastellos-Johnson demonstrating a prototype of their QUASR RT-LAMP reactions.

## Molecular Diagnostics Technique Goes Out to the Field to Keep Crops Safe

### CHALLENGE

It is vital for plant nurseries and commercial growers to know the health status of their plants before they take cuttings and propagate them, or deliver plants to customers. Yet sending samples for testing can be time-consuming. In the case of RNA viruses and viroids, delicate RNA molecules might not maintain their stability throughout the process of shipping to a lab, and if the sample was not kept cold enough, it may have degraded, producing a false test result. Additionally, there can be lab and shipping bottlenecks, making it difficult for the nursery to get results quickly.

### COLLABORATION

Purple City Labs was begun in 2021 by Ali Bektaş, a plant molecular biologist with a specialty in diagnostics. He uses RT-LAMP (reverse-transcription loop mediated isothermal amplification) frequently in his work, so became familiar with QUASR, a LAMP add-on technique developed by Robert Meagher, a chemical engineer at Sandia National Laboratories, and his team.

The quenching of unincorporated amplification signal technique was dubbed QUASR in honor of the extremely bright celestial objects known as quasars. This is because the technique greatly amplifies LAMP test signals, making them brighter and easier to read.

Originally developed to detect mosquito-borne viruses as part of Sandia’s national security mission, QUASR’s developers realized it could also be used to test for other pathogens, viruses, and diseases. Bektaş could also see QUASR’s potential.

### SOLUTION

After being involved in international discussions about how to scale up virus testing and bring it to the point of care for people during the COVID pandemic, Bektaş saw that a similar need existed for other species, like plants. He believed RT-LAMP, along with a reagent kit with high sensitivity and specificity, could bring the power of molecular diagnostics to the field, making it available outside of laboratory settings.

Bektaş licensed the Sandia QUASR technology and worked to incorporate it as part of Purple City’s reagent kits being marketed to plant nurseries. The addition of QUASR also presents the opportunity to multiplex, or detect more than one target at a time, and helps reduce the possibility of false positives.

### IMPACT

Many crops such as grapes, potatoes, hops, and apples are propagated vegetatively, so testing for disease-free plants with reliable, fast methods is crucial.

Using QUASR in plant testing can help ensure disease-free plants and healthy nurseries. Making sure the plant material being sent out across the country is healthy positively impacts the livelihood of farmers, maintains robust agricultural systems, and the integrity and security of the food supply.

**PARTNERSHIP TYPE:** License

**GOAL:** Keeping agriculture safe by bringing the power of molecular diagnostics to the field for fast, accurate test results

# LAWRENCE BERKELEY AND PACIFIC NORTHWEST NATIONAL LABORATORIES

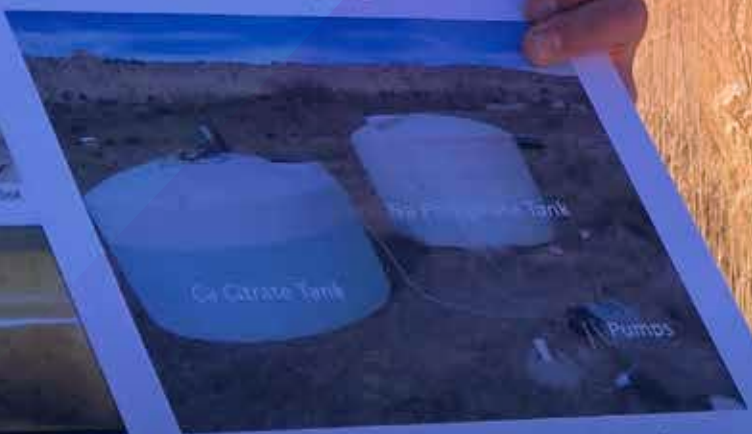


## In Situ Apatite PRB Using Water Soluble Reagents "Solutions for..."

calcium-(citrate), + sodium phosphate      soil microorganisms      →      apatite



Apatite crystals formed in soil



Apatite Field Injection Experiment

“Working with Sandia on this project has been particularly rewarding because the apatite-based approach for uranium remediation has been by far the most effective and long-lasting technology I’ve been associated with over my nearly two decades in the field.”

— Ken Williams

Senior Scientist

Environmental Remediation and Water Resources Program Lead

Lawrence Berkeley National Laboratory

Sandia Geochemist Mark Rigali presents the apatite remediation technology to legacy management stakeholders during a demonstration at the former uranium mill near Rifle, Colorado.

## “Garbage Can” Mineral Cleans Up Persistent Radioactive Contaminants

### CHALLENGE

Thousands of locations worldwide are contaminated with radioactive elements and heavy metals that threaten groundwater, surface water, and food supplies.

An apatite remediation technology invented by former Sandia National Laboratories Chemical Engineer Robert Moore has been successfully implemented at DOE’s Hanford site to protect the Columbia River from the radioactive isotope strontium-90. But could it also be used to remediate dissolved uranium in groundwater?

### COLLABORATION

A team of researchers from Sandia, Lawrence Berkeley (LBNL), and Pacific Northwest (PNNL) national laboratories set out to test Sandia’s apatite technology for uranium remediation at a former mill site in Rifle, CO, impacted by multiple contaminants.

Jim Szecsody of PNNL ran laboratory tests to confirm apatite would bind dissolved uranium under Rifle site conditions. By injecting the apatite-forming solutions in a series of wells in the path of the contaminants, a permeable reactive barrier of calcium apatite is formed. Mark Rigali of Sandia designed the apatite solution chemistry and injection strategy, and Jon Luellen of AECOM Nuclear and Environment Technical Services, LLC helped run the field tests.

Ken Williams of LBNL found that in addition to reducing the amount of uranium in groundwater more than ten-thousandfold, the apatite reduced the amount of vanadium by more than a hundredfold and molybdenum by a factor of twenty, with no increases in arsenic as seen with alternate remediation technologies.

### SOLUTION

Apatite is known as a “garbage can” mineral since it absorbs many radioisotopes and metals. To form apatite in the ground, the researchers used injection wells to place two inexpensive, nontoxic chemicals, calcium citrate and sodium phosphate, underground.

Once in the ground, soil bacteria consumed the calcium citrate solution releasing the calcium in a form that allows it to rapidly react with the sodium phosphate to form calcium apatite, which coats sand and soil particles underground. The apatite coating then captures radioisotopes and metals around the injection well. Afterwards, as the uranium and metal contaminated groundwater flows through the permeable apatite coating, it captures and holds these contaminants for millennia.

### IMPACT

In addition to the Rifle site, the patented apatite technology could be used at hundreds of other locations for uranium remediation, enabling the mission of protecting human health and the environment at legacy DOE sites. The technology is also tunable for the capture and storage of other contaminants such as heavy metals, arsenic, selenium, and lead.

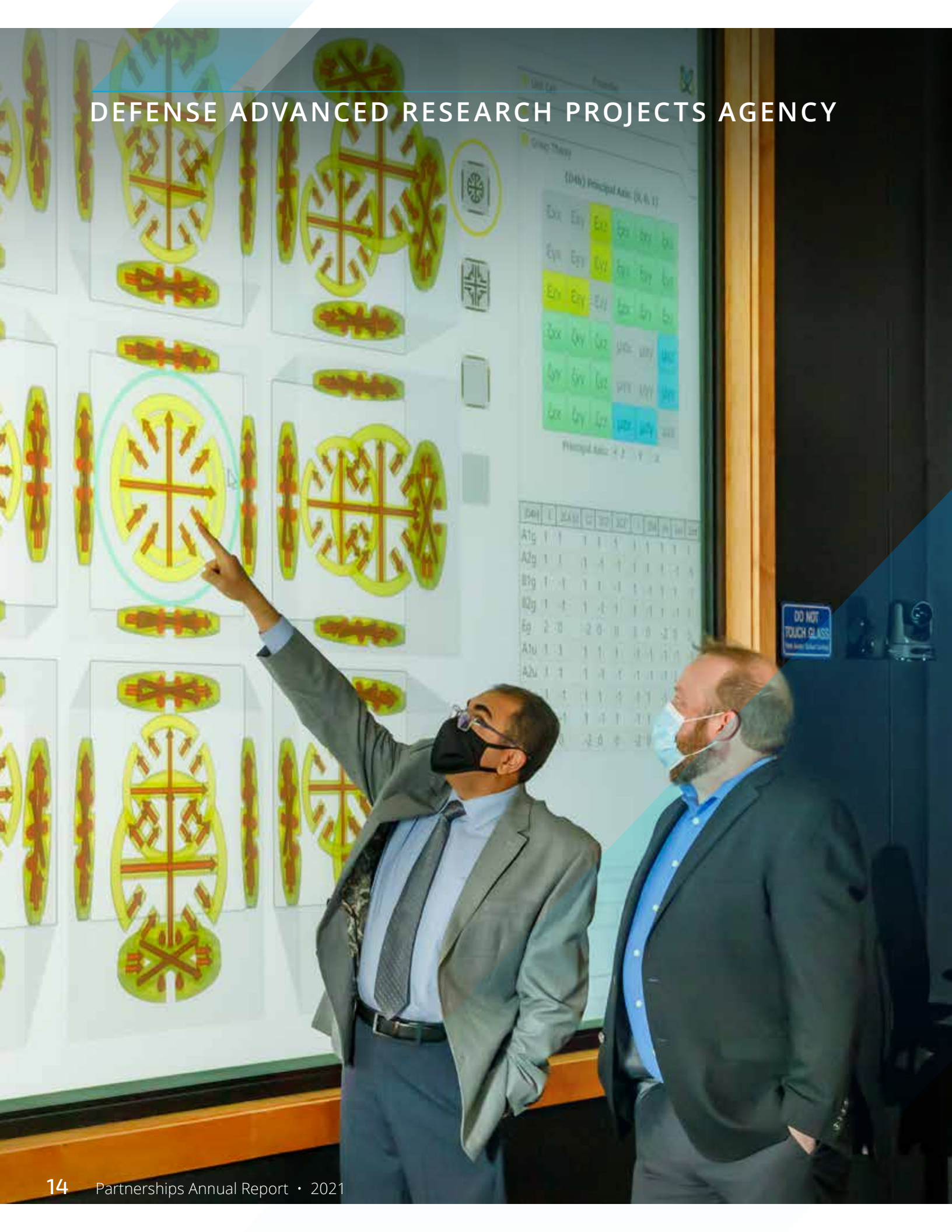
Currently, this apatite technology is being considered for remediation both nationally and internationally following this successful collaborative test.

**PARTNERSHIP TYPE:** Collaborative research funded through DOE’s Office of Legacy Management

**GOAL:** Cleaning up uranium and other radioactive contaminants worldwide with an extremely effective apatite sponge technology



# DEFENSE ADVANCED RESEARCH PROJECTS AGENCY





“In the development process, the Sandia team demonstrated exceptional sensitivity to DARPA’s needs and took into consideration all inputs from the Government team that monitored Sandia’s progress.”

— **Dr. Predrag Milojkovic**  
*Chief Scientist of  
 Photonics Electronics  
 Quantum and  
 Sensing Division  
 Electron Devices  
 Directorate  
 Army Research Lab*

■ Sandia MIRaGE Project Principal Investigator Ihab El-Kady and Stellar Science Lead Software Engineer David Fitzpatrick inspecting a metamaterial crystal structure and its performance in the MIRaGE toolkit.

## Software Takes the Guesswork Out of Designing Metamaterials

### CHALLENGE

Since their inception over two decades ago, man-made optical metamaterials have been promoted for their ability to manipulate light in extraordinary ways. This technology makes ultrahigh-resolution imaging and even cloaking materials possible. Yet the field has struggled to achieve its full potential because of its reliance on trial and error to find optimal configurations.

In late 2017 the Defense Advanced Research Projects Agency (DARPA) issued an announcement acknowledging the tremendous potential of metamaterials, but recognizing the severe deficiency in the computational tools available for their design.

### COLLABORATION

Sandia National Laboratories Researchers Ihab El-Kady and Charles Reinke argued in a 2011 paper that the best approach to metamaterial design would be to use group theory-based symmetry borrowed from chemistry. El-Kady decided to answer the DARPA call by building a tool to realize this approach, so he put together a team to accomplish this goal.

Sandia is world famous for the development of powerful computational tools for the modeling, simulation, and optimization of abstract problems. But these tools must be customized for each application. So in addition to his team of Sandia scientists, El-Kady hired Stellar Science, Inc. to design the front-end interface, making the planned software more accessible. The team also worked closely with DARPA and the National Geospatial Intelligence Agency (NGA) in an effort to make the new tool as powerful as possible.

### SOLUTION

Multiscale Inverse Rapid Group-theory for Engineered-metamaterials ([MIRaGE](#)) is the first software that applies inverse design methods for metamaterials. This means that users start by describing the result they want and the software fills in the steps to get there. This approach takes guesswork out of engineering as-yet theoretical technologies. DARPA and NGA have invested millions in MIRaGE and continue to fund further development of this technology that ties directly to Sandia’s national security mission.

A website was set up to facilitate licensing and transfer of the software. While the unrestricted version is free to research facilities and contractors engaged in government research, the restricted version is only available to government entities.

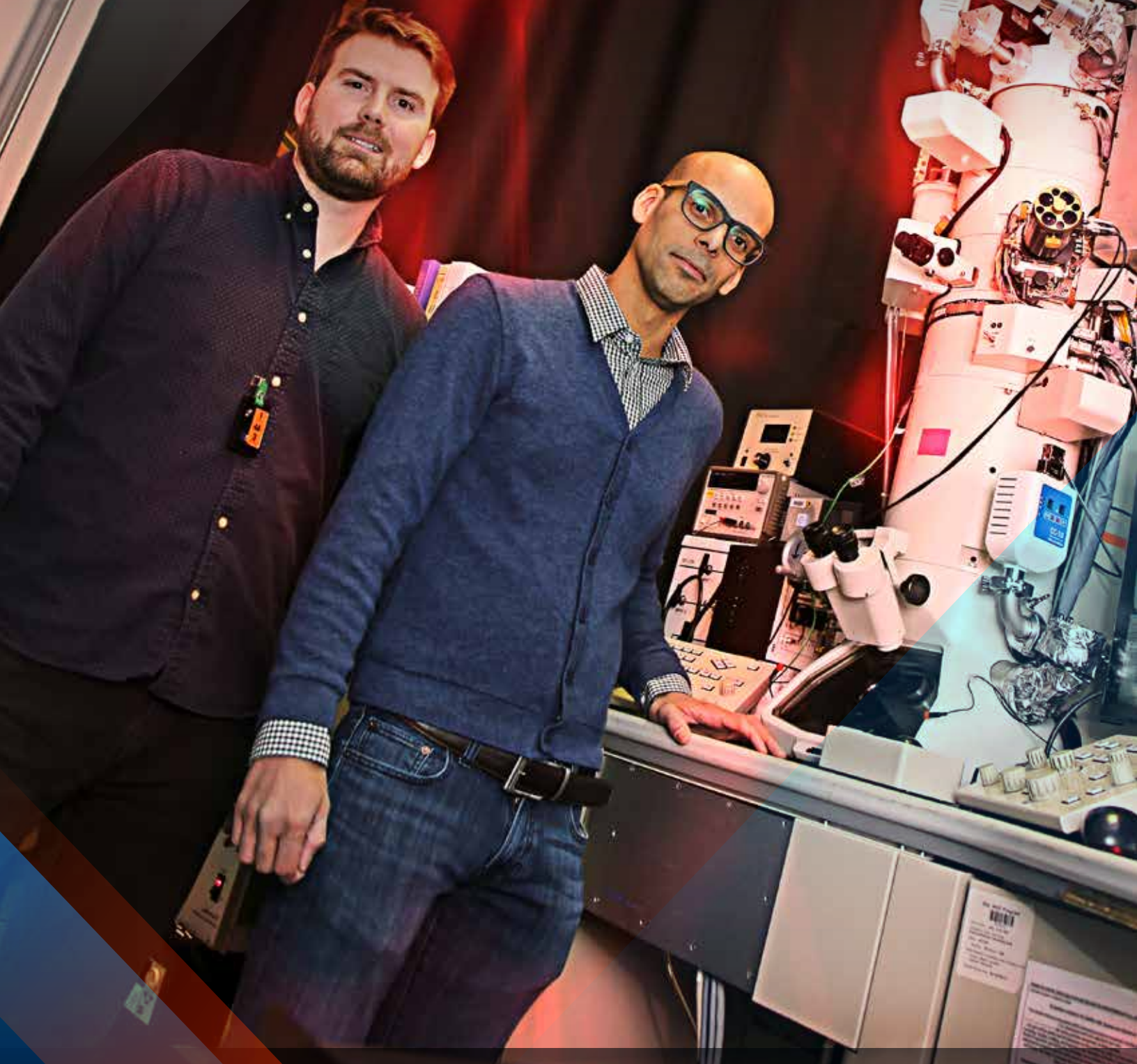
### IMPACT

MIRaGE is having an impact on national security, academic research, and the U.S. economy. One of the major outcomes of the technology transfer is that MIRaGE is being used to design a Fighter-Jet Optical Gimbal in collaboration with Northrop Grumman for the Air Force under direction from NGA. Currently, the technology is also part of DARPA’s latest night vision goggle development program, and is being used by university researchers to create 3D electromagnetic antenna designs.

**PARTNERSHIP TYPE:** *Government use license*

**GOAL:** *Speeding up metamaterial design through the use of inverse design methods making theoretical materials a reality*

# UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN



The long-term Sandia academic partnership with the University of Illinois enables collaboration across the breadth of research done at Sandia. In addition to mission-related research in engineering science, advanced materials design, and modeling and simulation, Sandia and Illinois collaborate in many other areas such as climate science, nuclear safeguards, cognitive science, applied statistics, energy infrastructure resilience, cybersecurity, genomic security, and human-machine teaming.

“Zirconia has been likened to ‘ceramic steel,’ and is critical to a wide range of applications. With the unique facilities and experienced staff at Sandia, we were able to broaden our understanding of this incredible material in real time under extreme conditions.”

— **Jessica Anne Krogstad**  
*Associate Professor*  
*Department of Materials Science and Engineering*  
*University of Illinois, Urbana-Champaign*

■ Former Sandian Christopher Barr and former University of Illinois at Urbana-Champaign Professor Shen Dillon in front of the In-situ Ion Irradiation Transmission Electron Microscope (I<sup>3</sup>TEM) at Sandia.

## Small Scale Testing Pushes Materials to Outer Limits

### CHALLENGE

People have been creating ceramics for thousands of years. But today’s ceramic materials are used for more than cooking. They undergo extreme high temperatures in situations like industrial processing and space flight.

There is little understanding of how materials deform at high temperatures due to mechanical stress because of the difficulty in duplicating the extreme conditions materials endure in some modern applications.

Tests have been performed on large samples, but it’s been almost impossible to see how damage occurs in nanoscale samples. This is especially true for zirconium dioxide (ZrO<sub>2</sub>), which melts at the extremely high temperature of 2715° C, too hot for conventional microscopes.

### COLLABORATION

[University of Illinois](#) at Urbana-Champaign professors and students have been working with a team of scientists at Sandia National Laboratories led by Khalid Hattar of the Center for Integrated Nanotechnologies (CINT). They’re developing a new way to test materials at high temperatures at the nanoscale. This work ties to Sandia’s mission to advance fundamental science to promote national security and international scientific leadership. The University professors were able to run experiments with their students and Sandia researchers on specialized equipment available at CINT.

This collaboration was possible because the University of Illinois at Urbana-Champaign is a valued Alliance partner in Sandia’s University Partnership Network, an initiative Sandia has formed with universities to promote collaborative research and attract top talent to work on tough problems.

### SOLUTION

In order to test the materials, two types of experiments were combined together in a transmission electron microscope (TEM): laser irradiation to heat the sample and compression to create stress.

The tight focus of the laser allowed the researchers to heat the samples to over 2000° C without overheating the microscope. This innovation let researchers capture time-lapse images of the experiments, which are helping scientists better understand how materials respond to high temperature processing or environments in varied applications.

### IMPACT

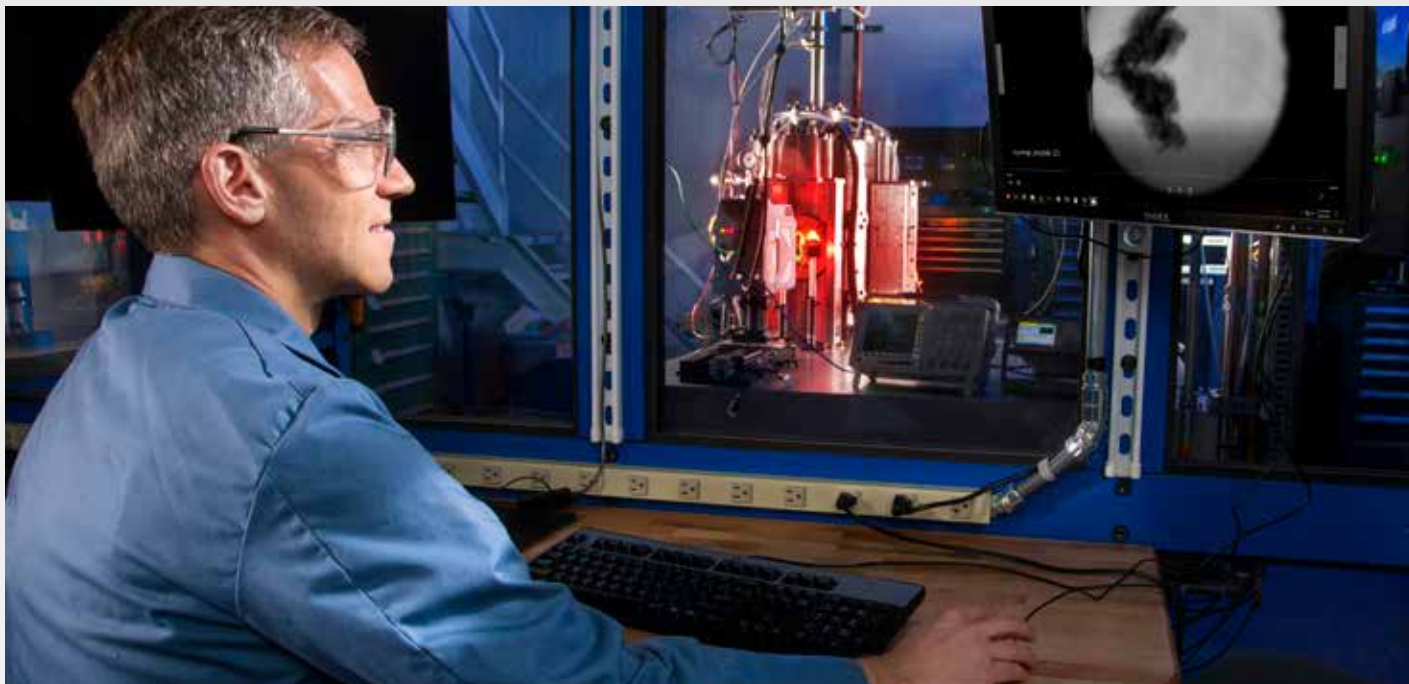
This new testing method can help engineers design stronger, safer mechanical parts. After the University and Sandia researchers ran experiments on ceramic materials and published papers, follow-on studies focused on more complicated materials like tungsten and depleted uranium. Parts that are used in systems as varied as light bulbs, spacecraft cladding, and nuclear reactors all undergo high temperatures and stress. All of the materials these parts are made of, and more, might be improved by studying them at the nanoscale in environments that replicate their use in the real world.

**PARTNERSHIP TYPE:** Sandia University Partnership Network

**GOAL:** Designing stronger, safer mechanical parts by studying ceramic materials at the nanoscale



# COMBUSTION RESEARCH FACILITY



## Consortium Furthers Future of Fuel Injection at CRF

Sandia National Laboratories researchers have partnered with industry, universities, and other institutions around the world to conduct experiments and modeling at the Combustion Research Facility (CRF) in Livermore, CA, since it was established as the first DOE user facility in the 1970s and designated a DOE collaborative research facility in 2008. The CRF is a center of scientific discovery and an important component of national economic competitiveness and Sandia's national energy security mission.

Research at the CRF helps to improve engine efficiency and reduce harmful tailpipe emissions, while also cutting net carbon dioxide emissions by using non-fossil sustainable fuels. The technology is applicable to cars and trucks as well as other modes of transportation that are particularly hard to electrify such as marine, rail, and aviation.

One partnership at the CRF is the industry-funded Spray Combustion Consortium (SCC), which currently includes industry partners Cummins, Convergent Science, Ford, Hino, Isuzu, Hyundai, and Toyota, as well as research partners Argonne National Laboratory and the University of Massachusetts-Amherst. The goal of the SCC is to provide better understanding and new computer models of fuel injection and fuel sprays. Industry uses these models to optimize the design of fuel injection and combustion systems in future engines.

Since it was formed in 2015, the SCC has provided over 30 unique research discoveries through combined experimental and modeling efforts. An early phase of the project addressed understanding internal flow within fuel injector nozzles, while the current phase includes research characterization and prediction of liquid vaporization and combustion under reacting conditions. The next phase, planned to begin in 2023, will focus on spray combustion using newer sustainable/renewable liquid and gaseous fuels.

■  
Lyle Pickett, primary lead for the Spray Combustion Consortium at Sandia, examines fuel injector spray characteristics in an optically accessible spray facility.

To learn more about CRF, visit [crf.sandia.gov](http://crf.sandia.gov)





## Z PULSED POWER FACILITY

### Z Helps Answer Question About Origin of Earth's Water

The origin of Earth's water remains one of the biggest mysteries in planetary science. Recently, evidence of large amounts of water deep in the Earth's mantle has been found. But how did this water get here during the planet-forming process? One hypothesis is that a significant reservoir of H<sub>2</sub>O was stored in silicate melts at depth during the magma ocean stage of Earth's evolution.

In order to further explore this question, Alisha N. Clark, an assistant professor at the Department of Geological Sciences, University of Colorado (CU) Boulder is running experiments at Sandia National Laboratories' Z facility. She is working with Sandia Researcher Jean-Paul Davis and his colleagues to utilize the Z machine's ability to reach the pressure-temperature conditions found deep within planetary interiors. This allows experiments done at the facility to offer a significant contribution to the resolution of an important question in planetary physics.

Because of its unique capabilities, such as providing an electrical current pulse of up to 26 million amps, Z can create large magnetic fields that generate very high temperatures and pressures. In Clark's experiments, the physical properties of hydrous and anhydrous silicate melts under extreme pressure-temperature conditions are being explored, using a shock-ramp technique made possible by Z's unique capability to shape the electrical pulse. Custom silicate glass samples are being provided by Corning Incorporated, a CU Boulder partner.

This project is just one of many being done at Z, the world's most powerful pulsed power facility, where research in areas including fusion, material properties, and radiation effects is performed. Research done at Z in fundamental science, such as astrophysics and planetary science, ties into Sandia missions by promoting national security and international scientific leadership.

■ Professor Alisha Clark with her graduate students Lindsay Harrison and Melia Kendall in front of the Thor pulsed-power machine at Sandia, where they are conducting experiments on hydrous silicate glasses to complement and inform experiments at the Z machine.

To learn more about Z, visit <https://www.sandia.gov/z-machine/>





# Distributed Production Smooths Transition to Hydrogen Energy

## CHALLENGE

Hydrogen is being touted as a clean source of energy. Yet hydrogen fuel cell vehicles are still not widely used, in part because of the production and transportation challenges for hydrogen fuel. Even when it is available, hydrogen can be expensive.

Currently, most hydrogen is produced in large, centralized hydrogen production plants, liquefied and transported

over long distances. But transportation of hydrogen is very costly and increases its carbon footprint. Up to one-half the cost of hydrogen fuel can be due to transportation.

## COLLABORATION

Researcher Robert Moore left Sandia National Laboratories to join [BayoTech](#), the company licensing and commercializing steam methane reforming technology he co-invented at the Labs. As BayoTech's Director of Research and Development, Moore continues to develop the technology for commercial applications. For Sandia, transferring the technology to industry helps the Labs fulfill one of its missions—to increase energy security and resiliency for the U.S.

■ Visitors receive a tour of the hydrogen production system at BayoTech's Center of Excellence in Albuquerque, New Mexico.





BayoGaaS Hydrogen Hubs are already being built and will be installed at customer sites throughout the United States and United Kingdom starting in 2022.

"We always keep our customers' needs in mind when developing our systems. That's why we've created a highly efficient and modular design using a unique bayonet nested flow reactor originally developed at Sandia. This system provides lower carbon emissions and cost of hydrogen."

— Wish Krishnamoorthy  
Chief Technology Officer  
BayoTech, Inc.

BayoTech is using the technology to make hydrogen from natural gas for distributed hydrogen production. The company has continued to develop the Sandia technology and supplement it with its own patented and patent-pending intellectual property.

## SOLUTION

By producing hydrogen on a smaller scale at distributed locations instead of a single large hydrogen production plant, the transition to hydrogen is being realized. BayoTech is commercializing on-site hydrogen production that is more efficient and less expensive than other alternatives.

The New Mexico-based company is planning a global network of its [BayoGaaS™ Hydrogen Hubs](#), with the first hub, located in Albuquerque, set to become operational in mid-2022. This unit will produce up to 1,000 kilograms per day of high-purity hydrogen for the New Mexico Gas Company, enough to fill as many as 200 hydrogen fuel cell vehicles.

## IMPACT

For BayoTech partner New Mexico Gas Company, the hydrogen produced by the BayoGaaS Hub will enable a pilot project where hydrogen will be blended with natural gas to be used for power, heat, and cooking. The hydrogen will also be available for other local customers, including retail hydrogen refueling stations and operators of fuel cell fleet vehicles and backup power systems. When using hydrogen produced from natural gas, fuel cell vehicles have 40% lower well-to-wheels greenhouse gas emissions than that of current gasoline-powered vehicles.

New Mexico Governor Michelle Lujan Grisham said, "BayoTech's investment in Albuquerque today will move New Mexico closer towards our ambitious goal of net zero carbon emissions by 2050." Along with agreements with hydrogen fueling center operators, it's also a step toward BayoTech's goal to become the world's largest distributed hydrogen company.

**PARTNERSHIP TYPE:** License

**GOAL:** Overcoming production and transportation challenges for hydrogen energy through the use of distributed production



## ENTREPRENEURIAL SEPARATION TO TRANSFER TECHNOLOGY



### New Company Moves Organic Glass Scintillator Technology to Market

Joey Carlson thought if he was ever going to start his own business, now was the time. While working on a new type of Organic Glass Scintillator (OGS) at Sandia National Laboratories, California, he had also taken part in some entrepreneurial training.

When he learned about Sandia's Entrepreneurial Separation to Transfer Technology (ESTT) program, Carlson saw that this was a good way for him to reduce the risk inherent in starting a new company. ESTT supports Sandia's technology transfer mission and allows employees to leave the Labs to start up or expand technology companies, with guaranteed reinstatement for up to two years.

As the co-inventor of OGS, Carlson knew he had the specialized knowledge required to give the technology its best chance for success in the marketplace. While developing the technology, he had also built relationships with collaborators including universities, companies, and research institutions. He knew what they needed.

OGS was being developed at Sandia to detect nuclear threats as part of the Labs' national security mission. OGS converts ionizing radiation into visible light that can detect and differentiate between some types of benign nuclear materials and those that might be a threat.

The interest in OGS technology has expanded from national security applications to nuclear physics experiments and medical imaging. [Blueshift Optics](#), Carlson's company, is licensing Sandia patents, working on proprietary manufacturing techniques, and selling several varieties of OGS products to customers.

Blueshift has received funding to adapt the Organic Glass technology to plastic scintillators. The company has contracted with Sandia to do joint research under a Strategic Partnership Project with the aim of improving plastic scintillators' detection capability while making them more manufacturable and less expensive.

Blueshift Optics Board Member Lauren Hines and CEO Joey Carlson inspect prototype scintillator plates for a nuclear physics experiment.

## NEW MEXICO SMALL BUSINESS ASSISTANCE

## Autonomous Systems Advanced with Lab Assistance

Emerging Technology Ventures (ETV) develops autonomous air and ground systems with integrated sensing/inspection and artificial intelligence driven predictive analytics for complex environments. The company, based in Alamogordo, New Mexico, provides systems, solutions, and services to government and commercial customers.

Cliff Hudson and his team had an idea to use drones equipped with artificial intelligence to remotely analyze possible damage on wind turbines. However, their limited resources meant that they needed help developing machine learning-based damage detection and assessment engines. Hudson approached the New Mexico Small Business Assistance (NMSBA) program, which linked him to Gabe Birch at Sandia National Laboratories, whose work focuses on computational and compressive imaging systems used for national security applications. Birch and his team analyzed the company-provided data set of blade damage to wind turbines, developed unsupervised learning anomaly-detection techniques, and refined the resulting algorithms using several hyperparameters to improve the software.

This technical assistance gave ETV the confidence to move forward with these innovative machine learning systems. Now ETV is serving customers in areas such as agriculture, aerospace, renewable energy, critical infrastructure, defense, and public safety. The technology is delivered through KeenAI, ETV's core technology, which provides end-to-end workflow services to autonomously sense, understand, decide, and act to provide critical, near real-time intelligence on issues affecting operations.

Since they received assistance from NMSBA, the company received \$200,000 from the U.S. Navy's ADAPT (Accelerated Delivery and Acquisition of Prototype Technologies) program, which led to the development of a prototype demonstration. They also won a NASA Phase 1 Small Business Technology Transfer (STTR) contract leveraging the same technology, were selected for the MassChallenge IBM Artificial Intelligence Mentorship program, and were awarded a State of New Mexico Small Business Innovation Research (NMSBIR) matching grant.

ETV team members show one of the AI-equipped drones they use for aircraft inspection and other applications.

To learn more about NMSBA, visit [www.NMSBAprogram.org](http://www.NMSBAprogram.org)



# SANDIA SCIENCE & TECHNOLOGY PARK



## Mural Partnerships Make Magic in the Park

A multitude of partnerships made the first public art installation in the Sandia Science & Technology Park (SS&TP) possible. The project brought together the City of Albuquerque's [Public Art Urban Enhancement Division](#), Meow Wolf Santa Fe, an award-winning artist, and Park companies and organizations.

The SS&TP is a 340-acre, master-planned technology community. Associated with Sandia National Laboratories and adjacent to Kirtland Air Force Base, it gives companies easy access to world-class facilities, technologies, scientists, and engineers. The SS&TP has many attractive amenities, but until now, it didn't have any public art.

[Cooperative Educational Services](#), a company in the SS&TP, offered a wall of its building for the mural. The artwork was funded by the Heising-Simons Foundation with support from the City's 1% for Public Art Program.

[Amanda Phingbodhipakkiya](#), a neuroscientist-turned-multidisciplinary artist and STEM advocate, created the artwork. The mural, titled "Limitless," shows women reaching toward each other within a landscape of bursting bubbles. The art represents what happens when electrons' orbitals overlap, connect, and activate. Similarly, when women collaborate, they can break free of their isolation, create, and make magic.

Phingbodhipakkiya collaborated with students from [Technology Leadership High School](#), located in the Park, on the mural. She met with them to talk about art and science; a week later, students came out to help paint.

"We're proud that partnerships with the SS&TP helped bring this science-themed mural to Albuquerque," said Mary Monson, Sandia senior manager for Technology Partnerships and Business Development. "Art inspires gathering, the exchange of ideas and invites people to pause, chat or think about themes they might not otherwise consider."

■  
Artist Amanda Phingbodhipakkiya stands in front of the completed mural in the SS&TP.

To learn more about the SS&TP, visit [www.sstp.org](http://www.sstp.org)





## TRGR TECHNOLOGY READINESS INITIATIVE

## Company Takes Solar Power to Space Faster with TRGR

[mPower Technology, Inc.](#) licensed solar technology originally developed at Sandia National Laboratories and is now taking it to space. Called microsystems enabled photovoltaics, or MEPV, when it was first invented, now the technology is being developed and marketed by mPower as [DragonSCALES™](#).

DragonSCALES are flexible, interconnected cells of highly efficient silicon that can be meshed into any shape or form. Leveraging well-established and affordable materials, processes, and tools from the silicon photovoltaic (PV) and microelectronics industries, DragonSCALES enable completely new design options for solar power.

mPower took part in the TRGR Technology Readiness Initiative as a member of the first cohort. TRGR is funded by the New Mexico State Legislature with the purpose of giving businesses the opportunity to utilize New Mexico national laboratory resources to mature their technology with up to \$150,000 of assistance. TRGR also helps Sandia fulfill its technology transfer mission.

Murat Okandan, who started mPower to transfer the technology he co-invented, says that through TRGR, the company was able to use the unique expertise and high performance computing resources available at Sandia to help with modeling and characterization to move the technology forward. Based on the results, mPower has been able to make design and process improvements to DragonSCALES, making them more resilient.

mPower achieved some milestones in 2021, including being chosen with Honeybee Robotics, Inc. in May to provide an innovative lunar charging solution for NASA. In July, DragonSCALES solar power modules were launched aboard a satellite by Lynk Global, Inc. into low-Earth orbit as part of an evaluation of the product's performance in space. Using Sandia licensed technology and assistance from TRGR are helping mPower prepare to supply reliable power for these and other space applications.

■  
mPower CTO and  
Founder Murat  
Okandan holds some  
DragonSCALES.

To learn more about  
TRGR, visit [www.nmtrgr.org](http://www.nmtrgr.org)



# QUANTUM SYSTEMS ACCELERATOR



## QSA Ecosystem Developing Quantum Workforce to Support Industry

It has been just over year since the DOE Office of Science awarded \$115M to the Quantum Systems Accelerator (QSA), a multi-institutional national center whose mission is to catalyze quantum research and ecosystem development. Co-led by Sandia National Laboratories and Lawrence Berkeley National Laboratory, QSA is making meaningful technical contributions to DOE priorities and supporting the quantum ecosystem.

QSA is pursuing advances in quantum information science and technology to co-design the algorithms, quantum devices, and engineering solutions needed to deliver certified quantum advantage in DOE scientific applications. More specifically, QSA is focused on advancements across some of the most promising qubit technologies; neutral atoms, trapped-ions, and superconducting circuits; pushing the art of the possible in each of these emerging quantum systems.

Led by Sandia's Technology and Economic Development Department, the QSA's Ecosystem team continues to bring together the quantum ecosystem, supporting industry engagement, preparing the next generation quantum workforce, and advancing diversity, equity, and inclusion. In year one, the Ecosystem team accomplished several critical milestones and objectives across each of these areas, and will continue building on its success in the years to come.

"QSA is already making progress toward creating novel quantum systems with advanced capacity and connectivity, allowing us to understand critical research directions to move the field forward. This work is complemented by broad outreach to transfer the technology and to develop the workforce that will be needed to realize and support these breakthroughs, paying special mind to ensuring that the quantum industry that results from these efforts is inclusive and diverse," said Sandian Rick Muller, deputy director of the QSA. The QSA team is excited to see what successes year two will bring.

■  
QSA Deputy Director  
Rick Muller presenting  
on the QSA to industry,  
academia, and  
government participants  
at the Q2B Practical  
Quantum Computing  
Conference.

To learn more about  
QSA, visit  
[www.quantumsystemsaccelerator.org/](http://www.quantumsystemsaccelerator.org/)



## COVID-19 TECHNICAL ASSISTANCE PROGRAM

## PV + Agriculture = Improved Grid Resilience and Income Opportunity

DOE's COVID-19 Technical Assistance Program (CTAP) was begun in 2020 to provide assistance for public health and economic recovery related technical challenges. Since the program began, there have been 13 projects funded at Sandia National Laboratories. In 2021, one of the projects was a partnership between Sandia and the Village of Questa.

Sandia Engineers Birk Jones and Michael Ropp studied how agrivoltaics might be used to improve grid reliability and resilience in Questa, New Mexico, a small, rural town that wanted to attract more businesses and residents to promote economic development.

Once they saw that there was farming being done in the community, the team thought about how agrivoltaics might have potential. Agrivoltaics combines agriculture and electric energy production by mounting photovoltaic (PV) systems above crops. The elevated structures allow for optimum light for plants and for farm machinery to access crop production.

Agrivoltaics would give land owners in Questa the opportunity to grow crops while also gaining income from power production. Creating a distributed energy network of PV systems with battery storage would also provide more energy resilience for the area. Crops could be grown for market with agrivoltaics and also as part of community gardens providing fresh produce to local residents.

Their preliminary assessment found that while the installation of an acre of PV with crops would cost about \$200,000 to install, it would result in \$17,000 in annual revenue. Water use could also be reduced as PV provides partial shade for crops, important in the dry, high-desert climate.

Other local stakeholders are currently joining with the Village of Questa to further study opportunities for research, development, and demonstration of agrivoltaics projects to create economic development opportunities for the community.

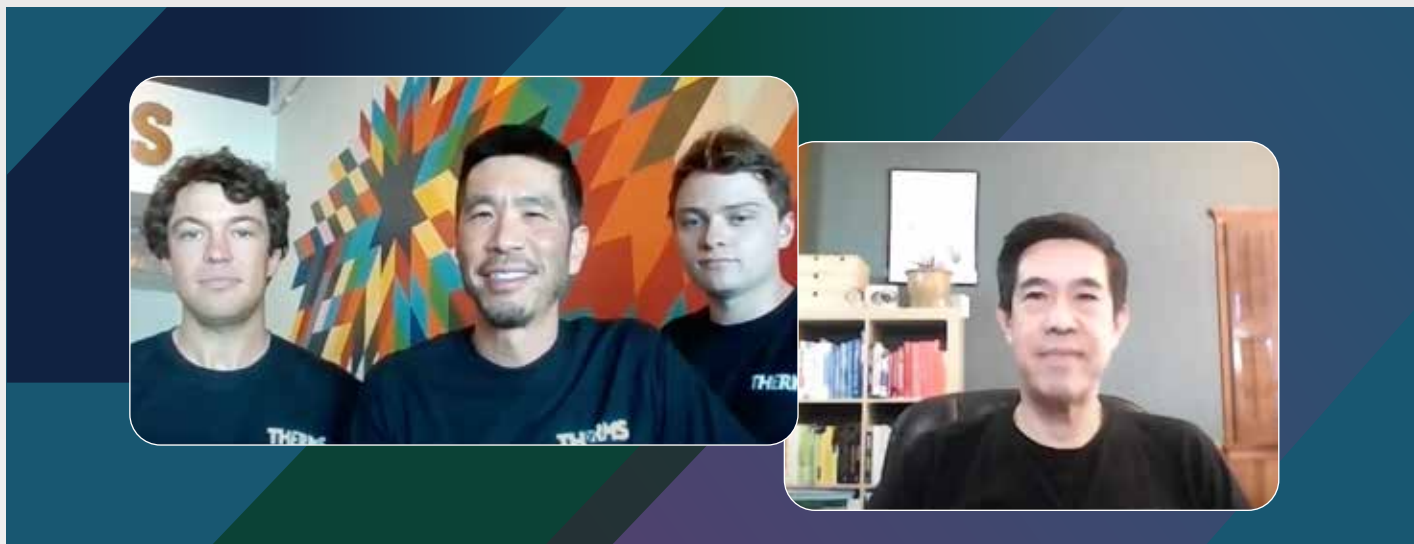
■  
**Sandia Engineers  
Michael Ropp and  
Birk Jones inspect  
solar panels.**

*To learn more about  
CTAP, visit [www.sandia.gov/working-with-sandia/ctap-2/](http://www.sandia.gov/working-with-sandia/ctap-2/)*





## ENERGY I-CORPS



### Sandia Technologies Move towards Market with Bootcamp Training

The DOE's Energy I-Corps had more teams than ever with 18 in [Cohort 12](#). This group included three teams from Sandia National Laboratories. A two-month bootcamp for national laboratory researchers, the program helps them learn about market needs for innovative technologies. Mentors from the private sector work with the researchers to give them industry perspectives.

The three Sandia teams worked on these technologies:

THERMS is a particle-based thermal storage technology that increases the security and resilience of the electrical grid in the face of increasing threats. THERMS uses inexpensive rock and/or sand-like particles that can be used for large-capacity, long-duration energy storage for electricity production or industrial process heat. This technology can be integrated with renewable energy and nuclear power plants.

MAD3 is a machine-learning solution that can instantly predict material's directional mechanical behavior from initial microstructural information without the need to perform costly and time-consuming experiments or high-fidelity simulations. MAD3 enables material scientists and manufacturers to develop accurate material deformation simulations 1000x faster than currently available software solutions, allowing for shorter product design cycles and faster time to market.

EPDR is a flexible electronic polymer dosimeter that can provide more accurate administration of radiation therapy while providing lower cost treatment and improved patient outcomes. The disposable adhesive patch can be applied directly to the patient's skin to measure radiation intensity and spatial distribution. The greater precision of EPDR will benefit patients and reduce operating and liability costs for treatment facilities.

Energy I-Corps is part of a DOE effort to move energy and national security technologies from the national labs to the marketplace, and ties to Sandia's technology transfer mission.

THERMS team of Henk Laubscher, Cliff Ho, Kyle Guin, and Gordon Ho giving their final Energy I-Corps program presentation.

To learn more about Energy I-Corps, visit <https://energycorps.energy.gov/>



## FEDTECH

## Technologies with Market Potential Paired with Startup Companies

FedTech identifies technologies from federal labs with market potential and pairs them with entrepreneurs to help move the technologies towards commercialization. The teams are trained in the lean startup model, work with mentors, and interview potential customers. Two teams aiming to commercialize Sandia National Laboratories technologies took part in the FedTech Startup Studio this year.

[Slipnot, LLC](#) wants to use Sandia's Twistact technology for a number of applications, including in direct drive wind turbines. As the size of wind turbines, especially those used offshore, is getting larger, with heavier, longer blades, a direct drive design utilizing Twistact instead of the traditional slip ring minimizes wear and the risk of catastrophic failure. The company has a Test and Evaluation license for the technology as they work on further development.

Twistact was originally invented by Sandia Researcher Jeff Koplow to eliminate reliance on rare earth magnets in utility scale direct-drive wind turbines. It overcomes the limitations of traditional rotary electrical contacts and is capable of operating over the 30-year service life of a wind turbine without maintenance or replacement.

Upp Bio was formed to commercialize Sandia's RetSynth software. RetSynth identifies pathways to the production of valuable molecular compounds using biological pathways derived from bacterial, algal, or fungal species and chemical steps in bioprocessing. For producing complex products, biological structures can be faster, less expensive, and more environmentally friendly. The company has signed a Test & Evaluation license with Sandia.

Using a novel algorithm, RetSynth can accelerate the research and development process for bioproduction. It sorts through large databases of biological and chemical reactions, helping scientists synthetically engineer compounds used in the production of biofuels, pharmaceuticals, cosmetics, industrial chemicals and more. Sandia Biologist Corey Hudson and his team developed RetSynth.

■  
A simple version of Twistact.

To learn more about FedTech, visit [www.fedtech.io/](http://www.fedtech.io/)



## LAB PARTNERING SERVICE



### Sandia Collaborates on Updates, Improving Partnership Portal's Usability

DOE's Lab Partnering Service (LPS) is a suite of online services providing access to people, projects, and patents from across the DOE national laboratories including Sandia National Laboratories. It provides a conduit between innovators and potential partners. In 2021, Sandia helped expand and improve the site to better showcase the national labs' capabilities and meet user needs.

Sandia collaborated with the DOE Office of Technology Transitions (OTT) and other DOE labs to help simplify the LPS website's taxonomy, or way the content is organized, in order to allow users to more quickly and effectively navigate and find the information they need. Users can now explore content by industry (e.g., energy and utilities, information and communications technology, manufacturing and industrial) or by popular topic (e.g., climate, COVID-19, biomanufacturing) to efficiently identify and connect with national labs that can help them address R&D or commercialization challenges.

The collaborators created subdomains for popular topics to showcase lab capabilities and expertise in emerging priority areas. In particular, Sandia helped synthesize information from across the labs for the climate subdomain, creating a framework covering the expanse of climate-related work and expertise at the national labs.

Sandia also developed a new grid modernization research facilities module with information on resources across the national labs. The module allows users to better understand the facilities and capabilities available at the national labs to meet their needs.

Finally, Sandia added new experts, success stories, facilities, and technology summaries to LPS, totaling approximately 260 new pieces of content in 2021. These additions support popular LPS topics and the site's expansion. They also resulted in approximately 30 inquiries from users interested in Sandia's capabilities and expertise.

■ Sandians Lauren Amagai and Jessica Knight look at the updated LPS website.

To learn more about LPS, visit [www.labpartnering.org/](http://www.labpartnering.org/)





## TEAMER

## Simulations Advance Wave Energy Converter towards Commercialization

The DOE's Testing Expertise and Access for Marine Energy Research (TEAMER) program is providing access to technical assistance in order to solve challenges and drive commercialization of marine renewable energy projects.

Sandia National Laboratories, with world-class expertise in water power technologies, has provided assistance on eight TEAMER projects since the program began in 2020. One of the first projects was with [Ocean Energy USA, LLC](#). The company, which is developing wave energy technology, requested help from Sandia to produce a high-fidelity computational fluid dynamic (CFD) model of their [OE Buoy](#) wave energy converter (WEC).

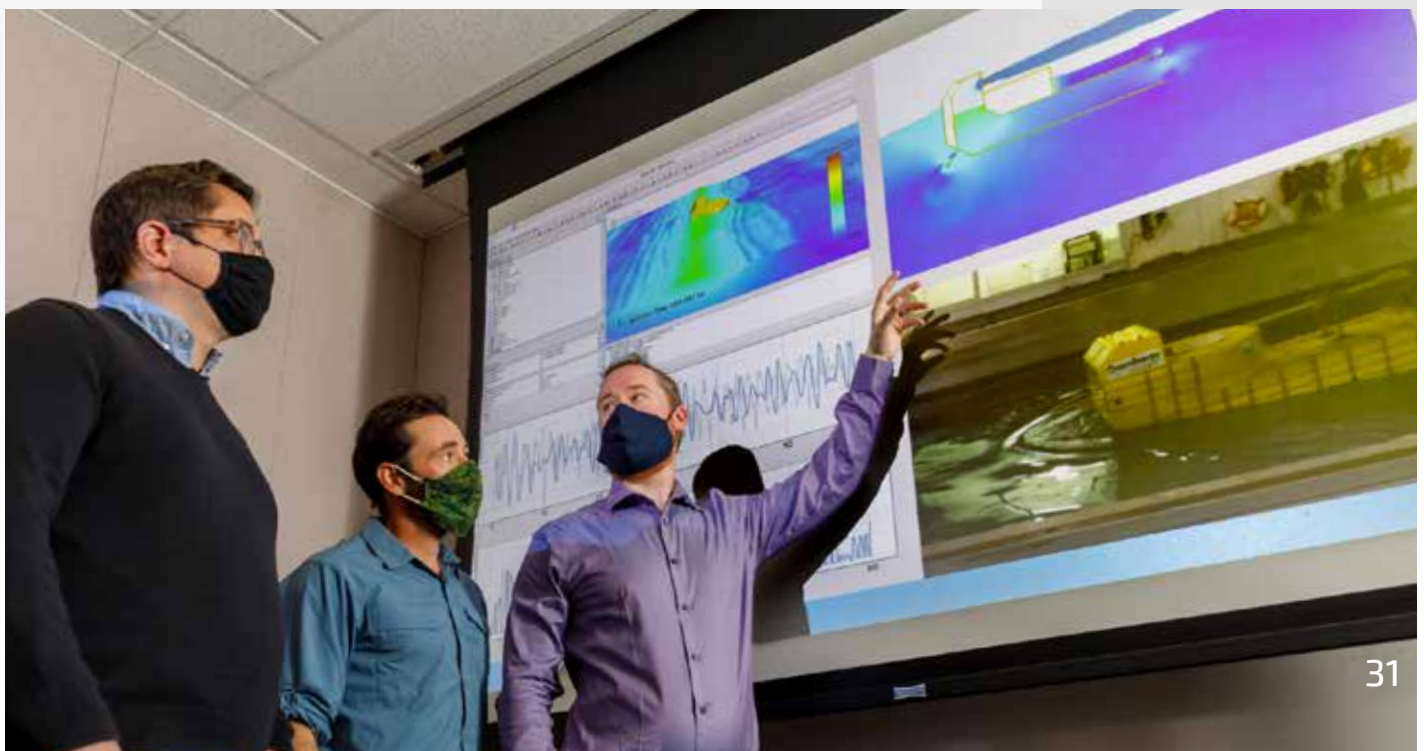
WECs transform wave motion into a sustainable source of power. The OE Buoy is a WEC which uses a floating hull to transform wave motion to pressurize air which turns a turbine and generates electricity. Ocean Energy has performed lab and open water testing as it continues to improve their technology.

Sandia has the high-performance computing resources and expertise necessary to run complex high-fidelity CFD simulations. Sandia has leveraged this unique capability for TEAMER to run simulations which predict the pressures inside and outside the walls of the OE Buoy hull under various wave conditions, from nominal to extreme sea states. This will help company engineers continue to optimize the hull structure design and select the optimal construction materials and air turbine. Since manufacturing and materials are the largest part of the cost, design improvements can lower the levelized cost of energy for WECs.

Now approaching commercialization, a 500 kW steel OE35 Buoy will be tested at the Navy's Wave Energy Test Site in Hawaii. The results from the Sandia-Ocean Energy TEAMER study will be relevant not only to Ocean Energy, but across the WEC industry.

■ Sandians Nathaniel deVelder, Jesse Roberts, and Chris Chartrand look at test results for the OE Buoy.

*To learn more about TEAMER, visit [www.teamer-us.org/](http://www.teamer-us.org/)*



# TECHNOLOGY COMMERCIALIZATION FUND



## New DC Power Conversion Circuit Part of Linked Microgrid Demonstration

Under an umbrella Cooperative Research and Development Agreement, [Emera Technologies, LLC](#) and Sandia National Laboratories installed a 250 kW hybrid DC/AC microgrid on Kirtland Air Force Base (KAFB). Now Emera Technologies and Sandia are partnering on a DOE Technology Commercialization Fund (TCF) project to work on interconnecting multiple microgrids and enabling bi-directional power flow between them.

TCF funds projects to accelerate the commercialization of promising energy technologies from DOE's national laboratories, create new jobs and businesses, and help the country move towards net-zero carbon emissions.

Emera Technologies is interested in DC microgrids because they have the promise to provide higher resiliency, facilitate integration of renewable resources, and become a viable enhancement to AC systems for supplying electricity to new industrial or residential areas. Sandia has experience working on microgrids used to supply critical military and civilian infrastructure and has developed a number of technologies as part of their energy security mission.

Based on the success of the single-bus microgrid at KAFB, adding other independent microgrids and linking them together is being investigated. But to enable these grid-of-grids that can be a part of the next generation of power distribution systems, advances in power conversion and safety for medium voltage DC systems are desperately needed. The HyGaiN DC power conversion circuit is Sandia technology that will be matured and deployed on the KAFB microgrid. The HyGaiN circuit will be utilized in two instances: first to directly connect a 600 V photovoltaic array to a grid-to-grid tie-line and second, the circuit architecture will be advanced to allow for bi-directional power flow as a grid-to-grid converter.

The technologies developed here will enable safe and high efficiency operation of this linked microgrid and demonstrate a path forward for incorporation of DC/AC microgrids on the current electrical system.

■ Electrical Engineers Andrew Dow and Jack Flicker study a prototype HyGaiN board that has red and black probes attached for monitoring voltage via an oscilloscope during testing.

To learn more about TCF, visit [www.energy.gov/technologytransitions/technology-commercialization-fund](http://www.energy.gov/technologytransitions/technology-commercialization-fund)



## RECOGNITION

### Innovation and Intellectual Property Celebrations



Annual Innovation and Intellectual Property (IP) Celebration events recognize Sandia National Laboratories scientists and engineers whose work created IP. The events also recognize Up & Coming Innovators, director nominated inventors who display enormous potential for supporting impactful innovations, exhibited entrepreneurial talent, and developed unique solutions to complex scientific challenges. Finally, they recognize Mission Innovators (Classified Innovation & Recognition Awards in California) for their technical and innovative contributions to our national security mission.

Due to the COVID-19 pandemic, an in-person celebration recognizing the calendar year 2020 patent holders, commercial copyright authors, Up & Coming Innovators, and Mission Innovators was not possible. However, the New Mexico Integrated Partnerships Organizations (IPO) was able to provide in-home recognition and awards to 109 patent inventors, 48 copyright authors, 15 Mission Innovators, and 13 Up & Coming Innovators. Sandia California recognized patent, copyright, and Classified Innovator award winners via a virtual innovation celebration with nearly 80 awardees from Division 8000 receiving a charcuterie board delivered to their homes.

### NMSBA Recognition

Projects that achieved outstanding innovations through the New Mexico Small Business Assistance (NMSBA) Program were recognized in the 2020 NMSBA *Perspectives* annual report, which also celebrated the program's 20th anniversary.

Four projects received technical assistance from Sandia. Analytical Technologies received help with developing a standalone charging station for personal electronic devices and began selling the product. The Microgenerator Leveraged project got assistance with a computer model of their microgenerator, leading to funding for the development of a prototype and new hires. Roadrunner 3D received help analyzing metal-based 3D printing technologies and now has a CRADA with collaborators working to develop refractory high-entropy alloys.

Emerging Technology Ventures was one of two projects that received the Honorable Speaker Ben Luján Award for Small Business Excellence for demonstrating the most economic impact. After receiving NMSBA assistance, the company received \$200,000 from the U.S. Navy to demonstrate their technology which uses machine learning and drones to inspect aircraft for damage. The technology can also be used to inspect wind turbines.

When the pandemic struck, NMSBA worked to make a difference. Selected COVID-related projects were fast-tracked to move assistance to companies as quickly as possible. These projects were also highlighted in *Perspectives*.

NMSBA assists for-profit small businesses in New Mexico with access to laboratory experts at Sandia and Los Alamos national laboratories. These experts help them gain knowledge and solve challenges utilizing the labs' cutting-edge technologies.





# AWARDS

## R&D 100 Awards

The R&D 100 Awards celebrate the year's 100 most innovative technologies. Sandia National Laboratories competes with universities, corporations, and other government laboratories for these prestigious awards.

### Individual Awards

#### [AeroMINE](#)



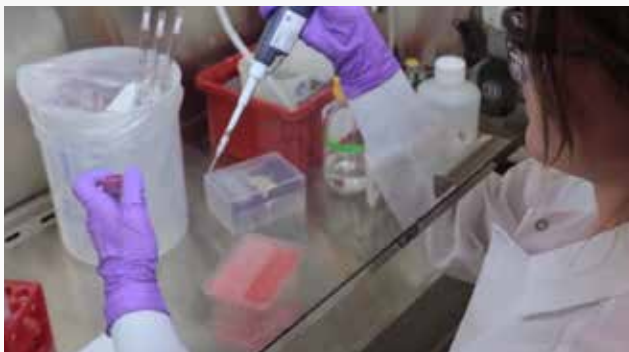
Co-developed with Westergaard Solutions Inc. and Texas Tech University, AeroMINE stationary wind harvesters provide safe, scalable, distributed electricity generation with no external moving parts. AeroMINES can complement rooftop solar or operate as standalone devices, providing affordable, and reliable renewable power.



#### [Potent and Effective Synthetic SARS-CoV-2 Neutralizing Nanobodies](#)



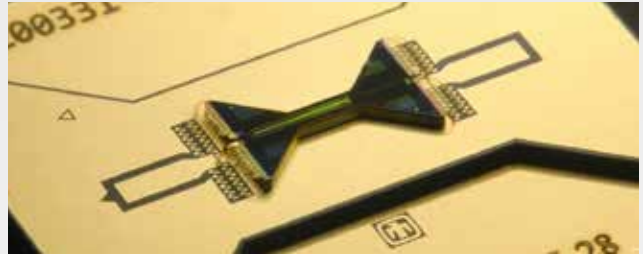
Using a library of variable antibody fragments called nanobodies, researchers have assembled extremely potent next-generation anti-COVID-19 neutralizing antibodies. Nanobodies offer easier manufacturability, increased versatility, smaller size, and the ability to bind to more than one target site to increase potency and resistance to viral mutants.



#### [Quantum Scientific Computing Open User Testbed \(QSCOUT\)](#)



The only open quantum computing testbed in the world based on trapped ions, QSCOUT gives the scientific community a new level of programming control and execution for improving quantum computer science, giving researchers the ability to study and answer major questions in quantum computing.



#### [RAPTR N95](#)

This is a reusable and rapidly producible N95 respirator for medical applications that can be completely disassembled with the intention of sterilization, decontamination, or component replacement. A swappable passive resonator transmits voice or can be used for fit certification. N95 filter media can be cut and placed in the protective structure, alleviating supply chain issues.



#### [Secure-Firmware Over-the-Air \(S-FOTA\)](#)

Firmware, or embedded software, requires frequent updates in most cars. But the update process is vulnerable to cyberattacks that can compromise critical functions. S-FOTA can be installed as a firmware plug-in in cars by the manufacturer and be remotely managed, without inconveniencing vehicle owners.

#### [Slycat](#)



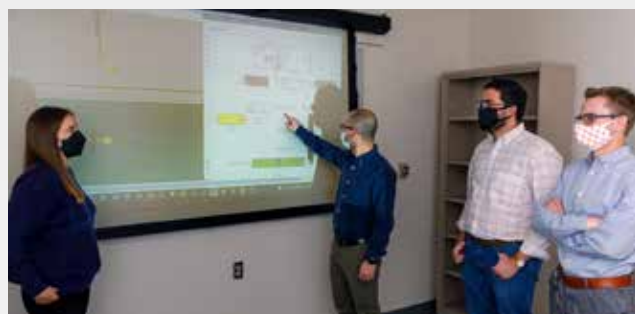
Computational modeling frequently generates collections of runs, known as ensembles. Slycat makes sense of ensemble data by integrating data management, scalable analysis, abstract visual representations, and remote interaction through a web-based interface.

### Joint Award

Sandia researchers won an additional R&D 100 award with a partner organization as well as two special recognition awards.

#### Wave Energy Converter Simulator (WEC-Sim)

The ocean is both a powerful source of energy and a formidable environment. WEC-Sim is the first open-source software allowing developers to simulate physical testing with computer modeling, which lowers costs and reduces R&D cycle time. The software is a multi-year collaboration with the National Renewable Energy Laboratory.



#### Green Tech Special Recognition Award



#### **GOLD Environmentally Benign Extraction (EBE) of Critical Metals using Supercritical CO<sub>2</sub>-Based Solvent**

Sandia researchers were recognized for a method that uses environmentally harmless citric acid in tandem with carbon dioxide to detoxify coal tailings by extracting critically needed rare elements and more harmful components at the same time.

#### **Corporate Social Responsibility Special Recognition Award SILVER RAPTR N95**

(see description on previous page).

## FLC Awards

The Federal Laboratory Consortium (FLC) Awards Program annually recognizes federal laboratories and their industry partners for outstanding technology transfer efforts.

### FLC National Awards

#### Excellence in Technology Transfer

#### mPower Technology



Sandia's Microsystems Enabled Photovoltaics technology is being further developed by mPower Technology for the space solar power market.

#### **Outstanding Technology Transfer Professional Bob Westervelt**

Licensing Executive Westervelt was honored for his unique set of knowledge and skills which have resulted in the transfer of many Sandia technologies and development of licensing best practices.

#### COVID-19 Response Award



#### Sandia's DF-200 Decontamination Technology

With the onset of the pandemic, multiple licensees have used DF-200-based products to protect the health of people worldwide.

## FLC Mid-Continent & Far West

### Region Awards Excellence in Technology Transfer

#### MIRaGE, a Futuristic Design Tool for Metamaterials



MIRaGE is the first software that applies inverse design methods for metamaterials, helping these artificial materials displaying unique optical properties live up to their potential.

#### Notable Technology Development

#### Binary Solvent Diffusion for Large Nanoparticle Supercrystals and Superior Sensors

This method to fabricate supercrystals has potential for applications in chemical detection as well as in nanoelectronics, optoelectronics, photovoltaics, and surface catalysis.

#### Wearable Diagnostic Monitor for Upcoming Seizure Events



Volatile organic compound biomarkers indicative of epileptic seizure onset are detected by a three-stage system using microfabricated and miniaturized chemical sensing technologies.

## Other Awards

### New Mexico Technology Council

#### Women in Technology Awards

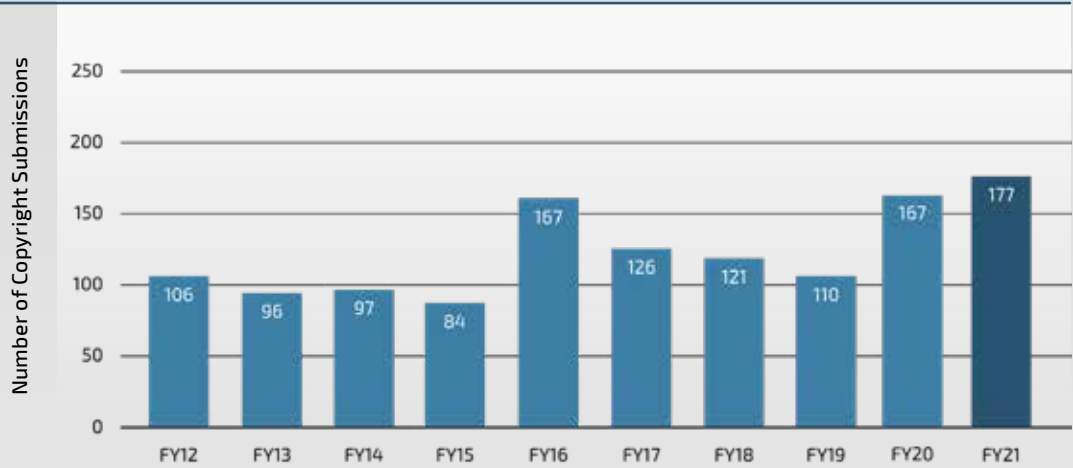
Sandra Begay was recognized her career at Sandia and her advocacy for diversity within the STEM fields.



# SCORECARD

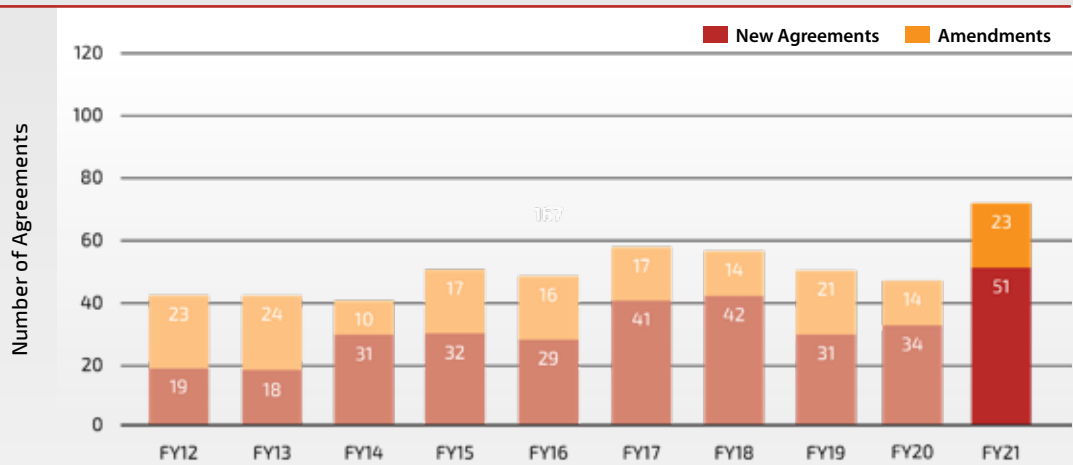
## Copyright Submissions

### Copyrights

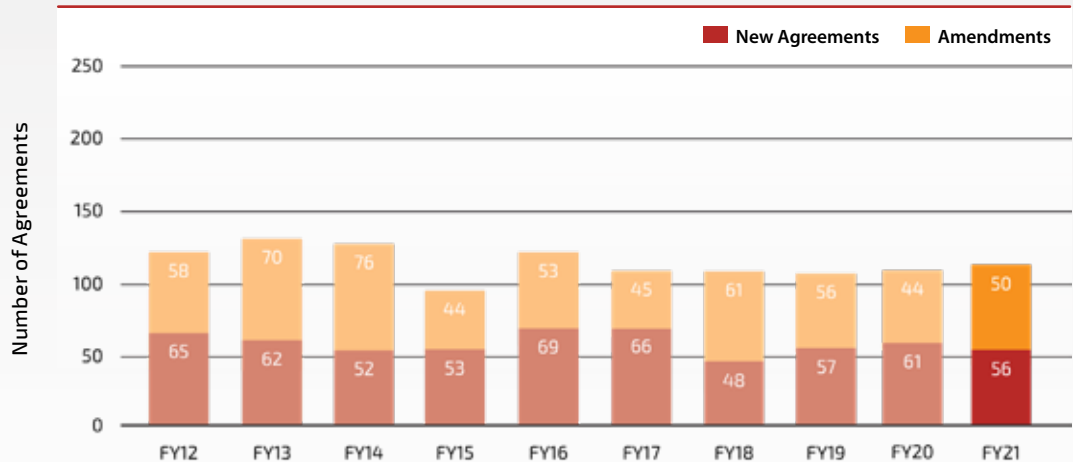


## Cooperative Research and Development Agreements (CRADAs)

### CRADAs and SPP/NFE Agreements



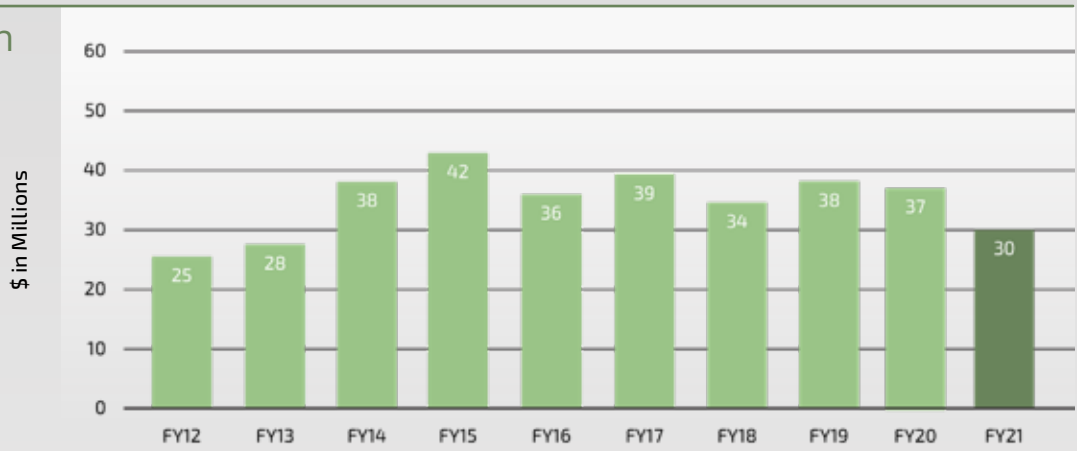
## Strategic Partnership Project/Non-Federal Entity (SPP/NFE) Agreements





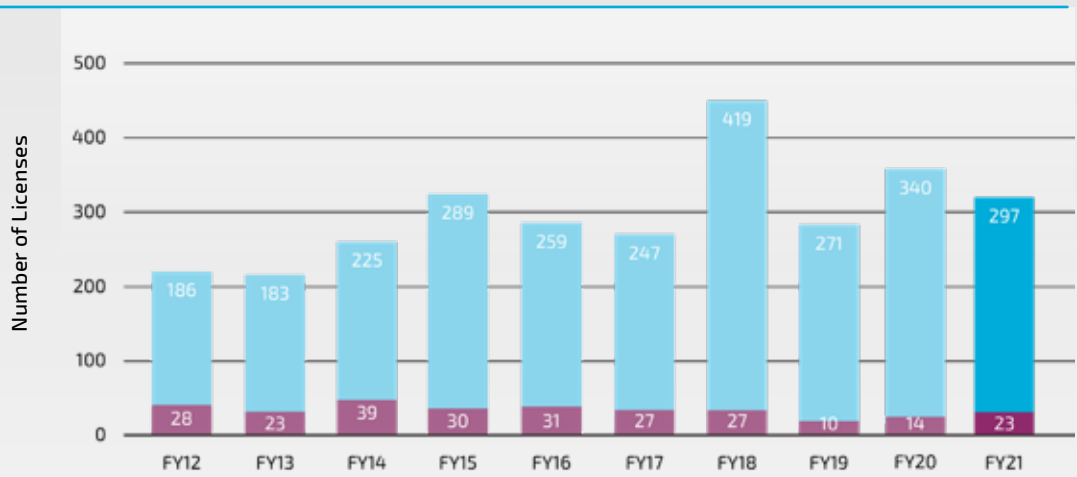
## Industry Funds-In

Industry Funds-In to Sandia (\$M)

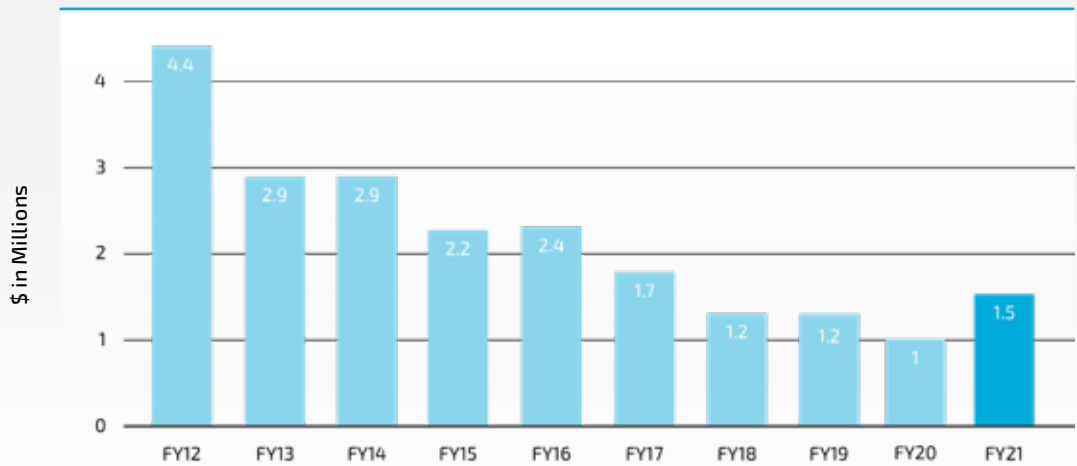


## Licenses

Licenses



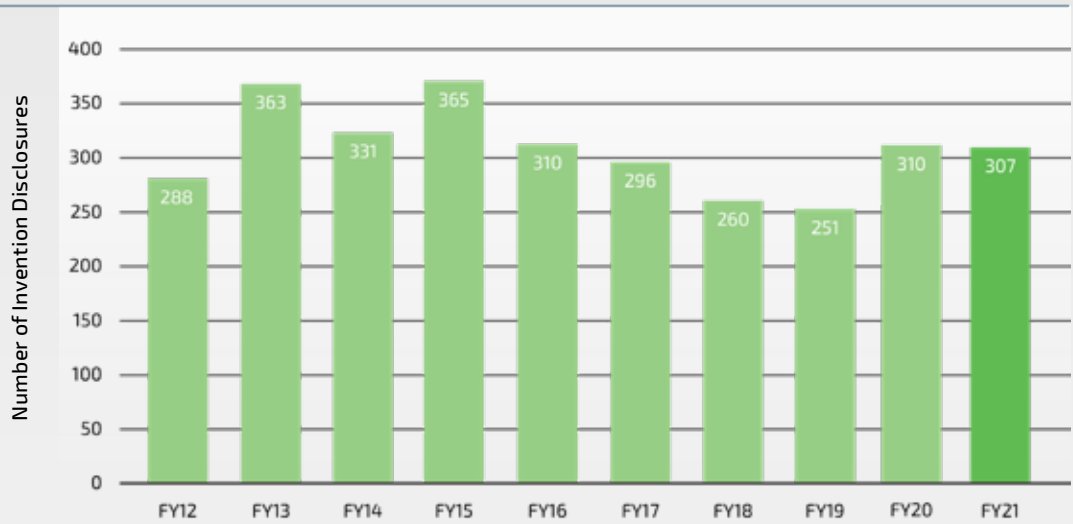
Licensing Income (\$M)



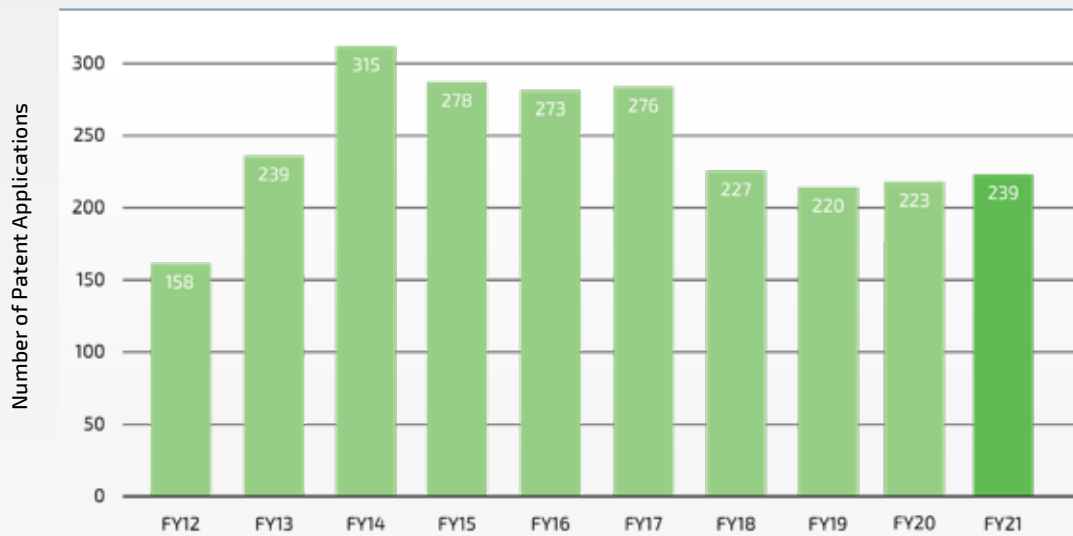
# SCORECARD

## Invention Disclosures

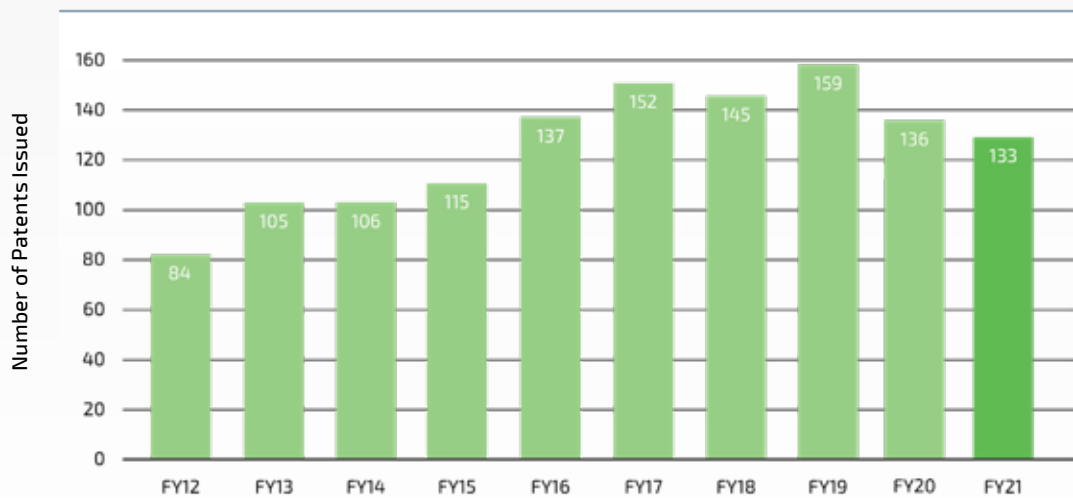
### Patent Activity



## Patent Applications



## Patents Issued



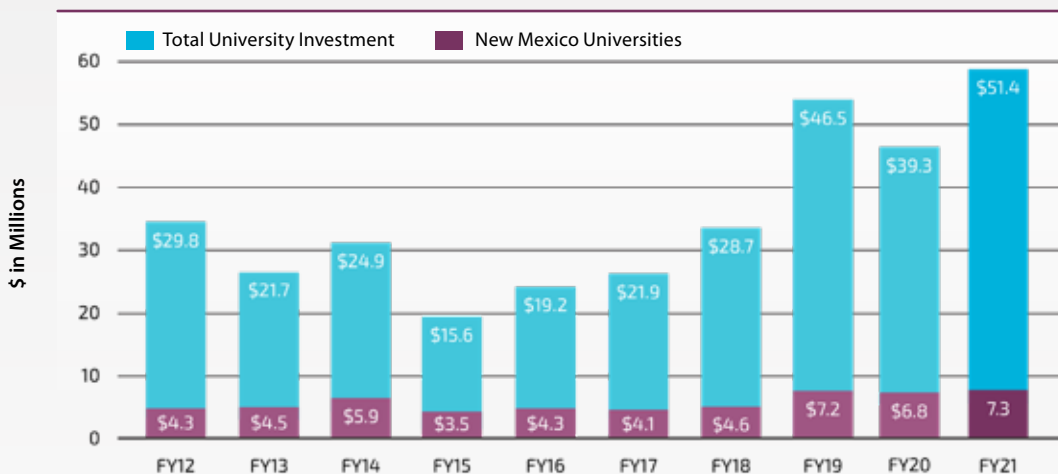
## University Partnerships

Since 1997, when the Campus Executive program was established, Sandia National Laboratories has formally cultivated university research to expand its science and technology base. Through the Campus Executive program, Sandia formalized agreements with about 20 schools that defined partnership goals, including research collaboration areas and talent pipeline objectives. In 2016, Sandia began more focused collaborations with a subset of the Campus Executive schools under its Sandia Academic Alliance Program. These schools had strong historical partnerships with Sandia, possessed synergistic research competencies and capabilities, and shared Sandia values and an affinity for national security work. In 2021, Sandia began its minority-focused program, Securing Top Academic Research and Talent (START) with Historically Black Colleges and Universities (HBCUs).

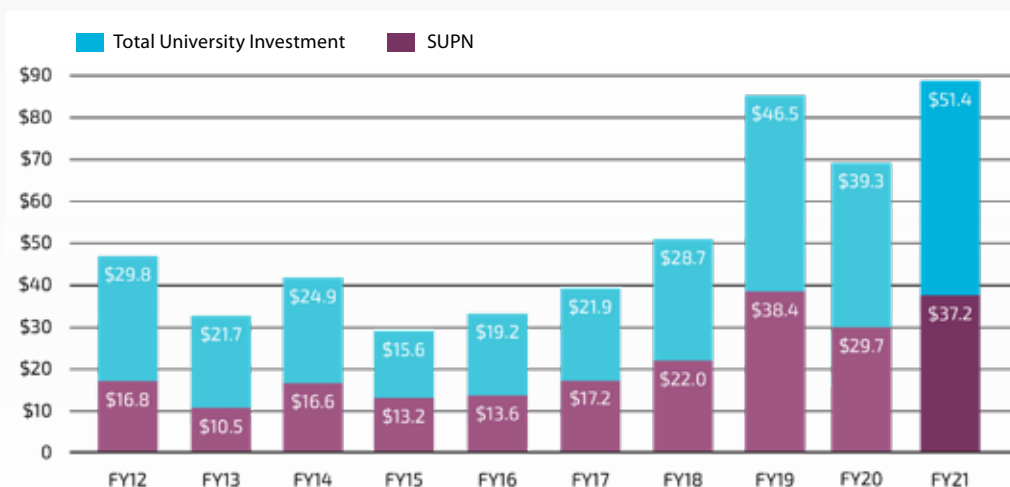
Sandia also revisited its strategy for university engagement in 2021, and is in the process of implementing the new Sandia University Partnership Network (SUPN). The SUPN is a graduated spectrum of relationships with universities across the United States. The objectives of the SUPN are to partner broadly with universities based on merit to ensure diversity in Sandia’s pipeline of top talent and innovative ideas, and to establish and cultivate enduring strategic and mutually beneficial relationships with a focused set of schools.

The Academic Programs Office, under the auspices of the Chief Research Officer, serves as the point of contact for university research, and implements those processes that enable and enhance university partnerships.

Investments in Research at New Mexico Universities\*



Investments in Research with Sandia University Partnership Network (SUPN)\*



These programs pair Sandia executives with university officials at schools that share research interests and capabilities.

\*Historic data has been updated to reflect current university structure and some investment numbers may have changed from previous reports.



## Sandia Science & Technology Park (SS&TP)

Companies and Organizations .....	40
Employees.....	1,786
Buildings .....	27
Public Investment in the Park*	\$99M
Private Investment in the Park*	\$317M
Total Investment in the Park*	\$416M
Increase in Taxable Consumer Spending*	\$4.0B
Increase in Wages*	\$7.2B
Average Salary of Full-time Jobs in Park .....	\$97K
Average Salary of Full-time Jobs in Metro Albuquerque .....	\$54K

\*Since Park opened in 1998.

### 2021

During the calendar year, one company moved into their new 18,000-square-foot building: Cooperative Educational Services; and one company is expanding their facilities from about 50,000 to over 123,000 square feet: BlueHalo.



## New Mexico Small Business Assistance (NMSBA)

	<b>Sandia: 2000-2021</b>
<b>New Mexico Small Businesses Assisted</b> .....	2,445
<b>Rural vs Urban Businesses</b>	
Rural (59%) .....	1,440
Urban (41%) .....	1,005
Combined .....	2,445
<b>Dollar Amount of Assistance</b> .....	\$46M

### Sandia and Los Alamos: 2000-2020\*

<b>Return on Investment (ROI)**</b> .....	\$1.54
(For every \$1.00 of state tax credit invested)	
<b>Economic Impact</b>	
Small Business Jobs Created and Retained .....	10,211
Average Reported Salary (2020) .....	\$54K
Increase in Revenue .....	\$459M
Decrease in Operating Costs .....	\$262M
Investment in NM Goods/Services .....	\$172M
New Funding/Financing Received .....	\$214M

\*Surveys are performed six months to one year after project completion.

\*\*ROI is based on salaries of jobs created and retained.

### 2021

During the calendar year, Sandia invested \$2.4M helping 130 small businesses in 15 counties throughout New Mexico. There were 68 Sandia principal investigators across 48 departments that supported NMSBA.



## Entrepreneurial Separation to Transfer Technology (ESTT)\*

<b>Sandians Who Left on ESTT</b> .....	170
To Start up a Company .....	78
To Expand a Company .....	92
<b>Companies Affected by ESTT</b> .....	120
Start-up Companies .....	61
Expansion Companies .....	59

\*Since ESTT began in 1994.

### 2021

During the fiscal year, four Sandians were approved to leave on ESTT and one Sandian returned to the Labs.



## TRGR Technology Readiness Initiative\*

Companies Assisted .....	9
New Licenses .....	7
New CRADAs .....	2

\*Since TRGR began in 2020.

### 2021

The State Legislature extended TRGR funding to 2027. Sandia will receive \$1M per year to assist New Mexico companies.



## Integrated Partnerships Organizations

For information about specific partnership areas, contact the following:

### Technology Partnerships & Business Development

Mary Monson, 505-844-3289, mamonso@sandia.gov

### Business Development & Data Analysis, Visualization, and Communications

Monica L. Martinez, 505-844-6131, monmart@sandia.gov

### Technology Partnership Agreements, Intellectual Property & Business and Competitive Intelligence

Joel Sikora, 505-284-1009, jsikora@sandia.gov

### Technology & Economic Development

David Kistin, 505-845-9723, dkistin@sandia.gov

### National Security Partnerships & Business Development

Candice Siebenthal, 505-284-5425, cssiebe@sandia.gov

### Global & Nuclear Security Partnerships & Business Development

Jon Chavez, 505-844-3179, jonchav@sandia.gov

### Business Development & Technology Partnerships (California)

Michelle Gonzalez, 505-238-6632, mjgonz2@sandia.gov

## Academic Programs

For information about Academic Programs, contact:

Diane Peebles, 505-845-8087, dpeebl@sandia.gov



## Partnerships National Reach

Explore our interactive data map which illustrates the amazing breadth of work Sandia National Laboratories does with industry, university, government, and lab partners around the U.S.

[https://www.sandia.gov/partnerships\\_reach/](https://www.sandia.gov/partnerships_reach/)



The Partnership Annual Report contains some photography taken prior to the COVID-19 pandemic. Photos taken more recently followed social distancing and other health and safety guidelines.



Thank you to everyone who contributed to this report.

## Partnerships Annual Report Team

### Sandia National Laboratories

David Kistin, *Manager*

Linda von Boetticher, *Report Project Manager*

Victoria Aranda, *Designer*

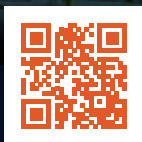
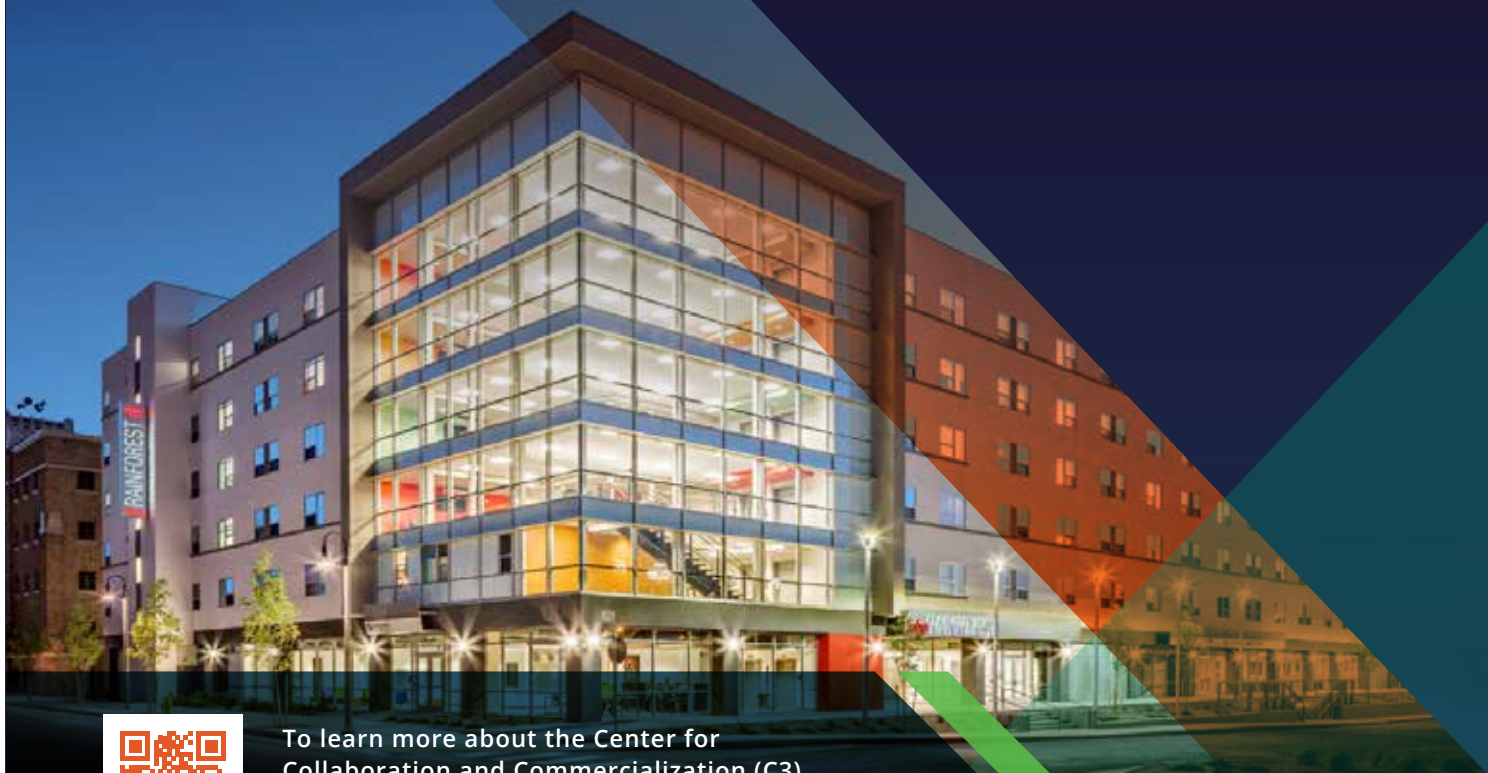
### Contractor

Ellen Cline, *Copywriter*

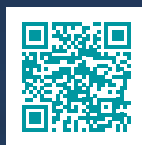
*Photos from BayoTech; Dino Vournas, Circuit Media; Tashina Jasso, Office of Legacy Management, DOE; Office of Technology Transitions, DOE; Lifeloc Technologies; Purple City Labs; Mary Beth Villanueva, Sandia Field Office; and Lonnie Anderson, Steven Dean, Jake Douglass, Rebecca Gustaf, Clifford Ho, Bret Houchens, Bret Latter, Mark Means, Randy Montoya, David Nagel, and Eric Ou, Sandia.*



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To learn more about the Center for Collaboration and Commercialization (C3), visit [www.C3abq.com](http://www.C3abq.com), or stop by our partnership space in downtown Albuquerque at 101 Broadway NE



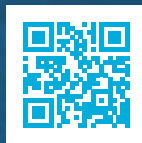
To learn more about industry or university partnership opportunities with Sandia, visit [www.sandia.gov/partnerships](http://www.sandia.gov/partnerships) or contact us at [partnerships@sandia.gov](mailto:partnerships@sandia.gov)



To learn more about licensing and technology transfer at Sandia, visit <https://ip.sandia.gov> or contact us at [ip@sandia.gov](mailto:ip@sandia.gov)



To learn more about academic partnerships at Sandia, visit [www.sandia.gov/working-with-sandia/academic-partnerships/](http://www.sandia.gov/working-with-sandia/academic-partnerships/) or contact us at [acadalli@sandia.gov](mailto:acadalli@sandia.gov)



To learn more on how to do business with Sandia, visit <http://sbu.sandia.gov> or contact us at [supplier@sandia.gov](mailto:supplier@sandia.gov)