

SANDIA NATIONAL LABORATORIES

Partnerships

ANNUAL REPORT FY2019



From Waste to Fuel
with New Biofuel
Production Process



Sandia
National
Laboratories



"As we investigate and explore new ways to accelerate the commercialization mission of the Department of Energy, we rely on our national laboratories to continue to pursue excellence in this increasingly important arena. This report is a testament to Sandia's strong commitment to technology transfer as a force multiplier for our nation's economic competitiveness and security, and I commend the Labs' staff for another successful year."

— Conner Prochaska

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



"These technology partnerships unleash remarkable innovations that enable mission success. Technologies transferred to private industry have immediate impact to improve our society and strengthen our nation's security."

— Dan Sanchez

*DOE Technology Partnerships Manager
NNSA Sandia Field Office*

"Innovation and technology development are vital to national security. Sandia's dynamic Partnerships Program extends the Labs' innovative technologies to the marketplace where they strengthen our country, promote economic competitiveness, and improve the quality of Americans' lives. Technology transfer through alliances with industry, academia, and government supports Sandia's national security missions, and we seek to grow our impact."

— James S. Peery

*Laboratories Director
Sandia National Laboratories*



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About the cover:

Sandia researchers Lalitendu Das, Harsha Magurudeniya, and Ezinne Achinivu use an Andritz reactor to conduct a one-pot pretreatment of California woody biomass for fermentation at Aemetis.

See story on page 18.



INTRODUCTION



"At Sandia, partnerships are of critical importance. Through collaborations with industry, academia, and other national laboratories we leverage capabilities, expertise, and facilities to develop new technologies and deliver on our national security mission. Moving our inventions to industry through tech transfer is a national security mission."

— Susan Seestrom

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



"Sandia realizing its motto of "Exceptional Service in the National Interest" can only be accomplished through sustained university partnerships. These collaborations include fundamental scientific and engineering discovery on challenging problems through our core research programs. More importantly, these relationships form a pipeline of extraordinary talent at Sandia that can provide impact to our national security mission."

— Basil Hassan

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



"Sandia is an active participant in DOE and NNSA programs dedicated to maturing and commercializing laboratory-developed technologies. In addition, we continue to develop innovative partnership programs of our own. These programs help Sandia fulfill its technology transfer mission and strengthen America's competitiveness."

— Mary Monson

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

Partnerships Promote Return on Investment

Sandia National Laboratories has always been a leader in technology transfer and strives to maximize the value of federal research investments. Partnerships with industry, other national laboratories, government agencies, and universities are a proven method for moving technology from the Labs to the marketplace.

Sandia has implemented several innovative technology partnerships approaches in support of the national goal to accelerate the transfer of technology to promote economic growth and national security.

In this annual report, we share these innovative approaches and just a small selection of the hundreds of Sandia partnerships. Among the topics, you'll read about how these collaborations are:

- Creating a compact portable refueler to extend driving range and support commercialization of hydrogen fuel cell vehicles
- Developing new, efficient, economically viable ways to create biofuels from biomass
- Improving the reliability of hydrogen infrastructure materials to enable large scale use of hydrogen as an energy carrier
- Preparing the country to respond to natural and adversarial events to ensure reliable and resilient energy delivery
- Developing a high-fidelity benchmark experiment supporting the validation of software used in nuclear design and safety analysis

Technology transfer promotes economic development including new products, companies, and jobs. Sandia partnerships not only help the Labs deliver on its national security mission, they also provide a valuable return on investment for the country.



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

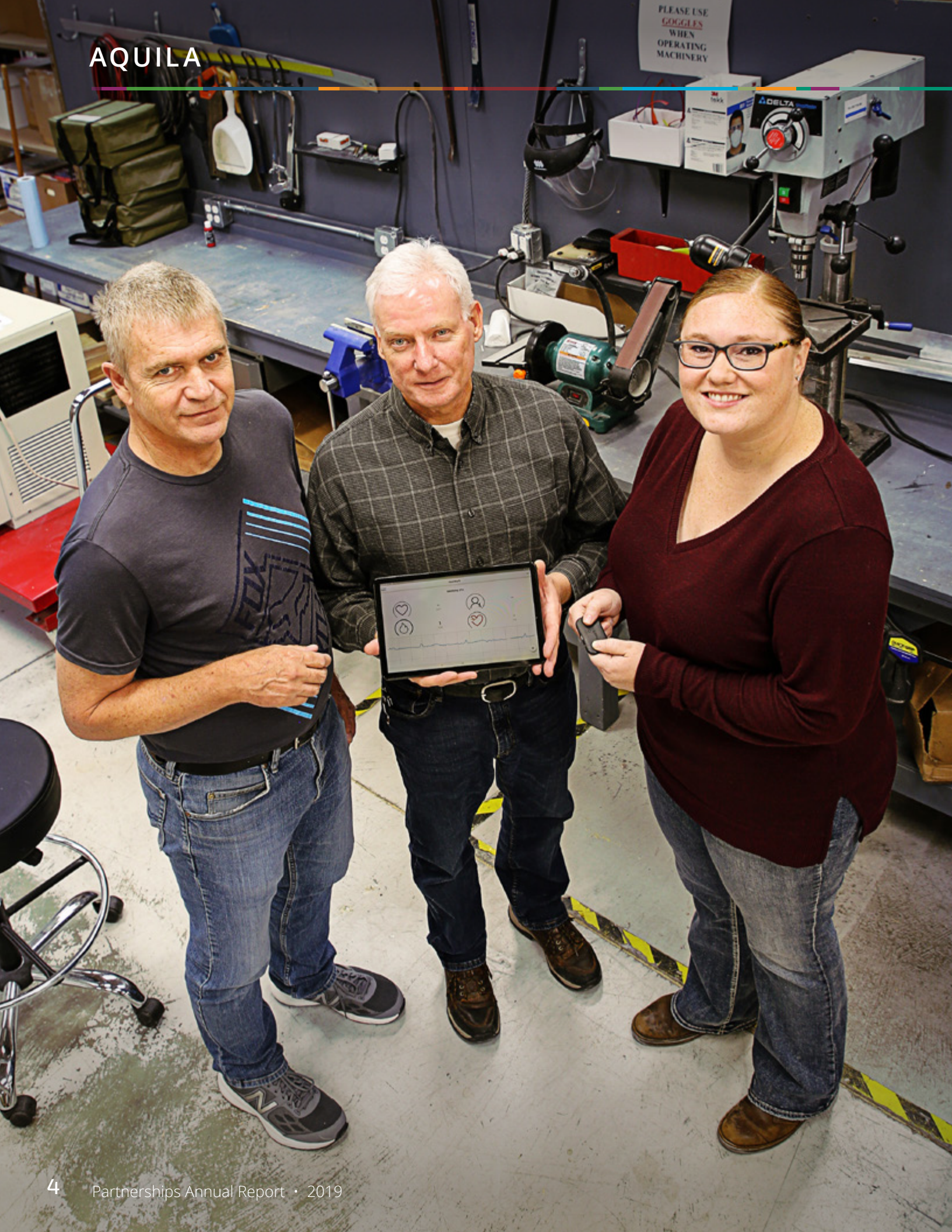


To learn more, visit
www.sandia.gov/ldrdd

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.



“Aquila has been a long-time partner of Sandia and we look forward to our collaboration and commercialization of this product.”

— Steve Kadner

*Executive Vice President
Aquila, Inc.*

Access Control and Security Using Electrocardiogram Signatures

CHALLENGE

Biometric security systems which grant access based on fingerprints or eye scans are becoming more common, but in some cases these authentication methods are impractical. When people are wearing gloves and safety glasses, such as in laboratory or hospital settings, how can they gain access?

COLLABORATION

[Aquila](#), a small, employee-owned company in New Mexico, has a long history of working with Sandia National Laboratories on cooperative development projects, including those related to secure environments. The company has the ability to design, develop, and manufacture technical devices. This complements Sandia’s expertise with systems where enhanced physical security and access control are necessary for domestic and international threat-reduction initiatives. It also ties to Sandia’s mission to help secure nuclear and radiological facilities.

Together, Sandia and Aquila are looking at how to use electrocardiogram (ECG) signatures as a security measure. An ECG is a record of the heart’s electrical activity during a heartbeat. There are several different measurable features, which together produce an individual signature.

SOLUTION

Unlike a fingerprint or eye scan, an ECG can be used to control access as well as possibly provide a means of constant authentication and tracking in high security areas. Sandian Andy Anderson had this idea in 2015 before he retired, and now the technology is finally at a stage where it is becoming feasible and more readily available.

Aquila will be using software developed by U.K.-based B-Secur that enables a heart rate and other wellness indicators to be streamed in real time. The company will integrate and modify the software as needed with hardware they are designing to create a product prototype. With Sandia, they will test the prototype system’s performance, including communications with the access-control architecture and tracking within conditions similar to those in a secure facility.

Various designs, such as a wristband or chest strap, will be considered and explored. The goal is to develop a device that is comfortable to wear for extended periods of time.

IMPACT

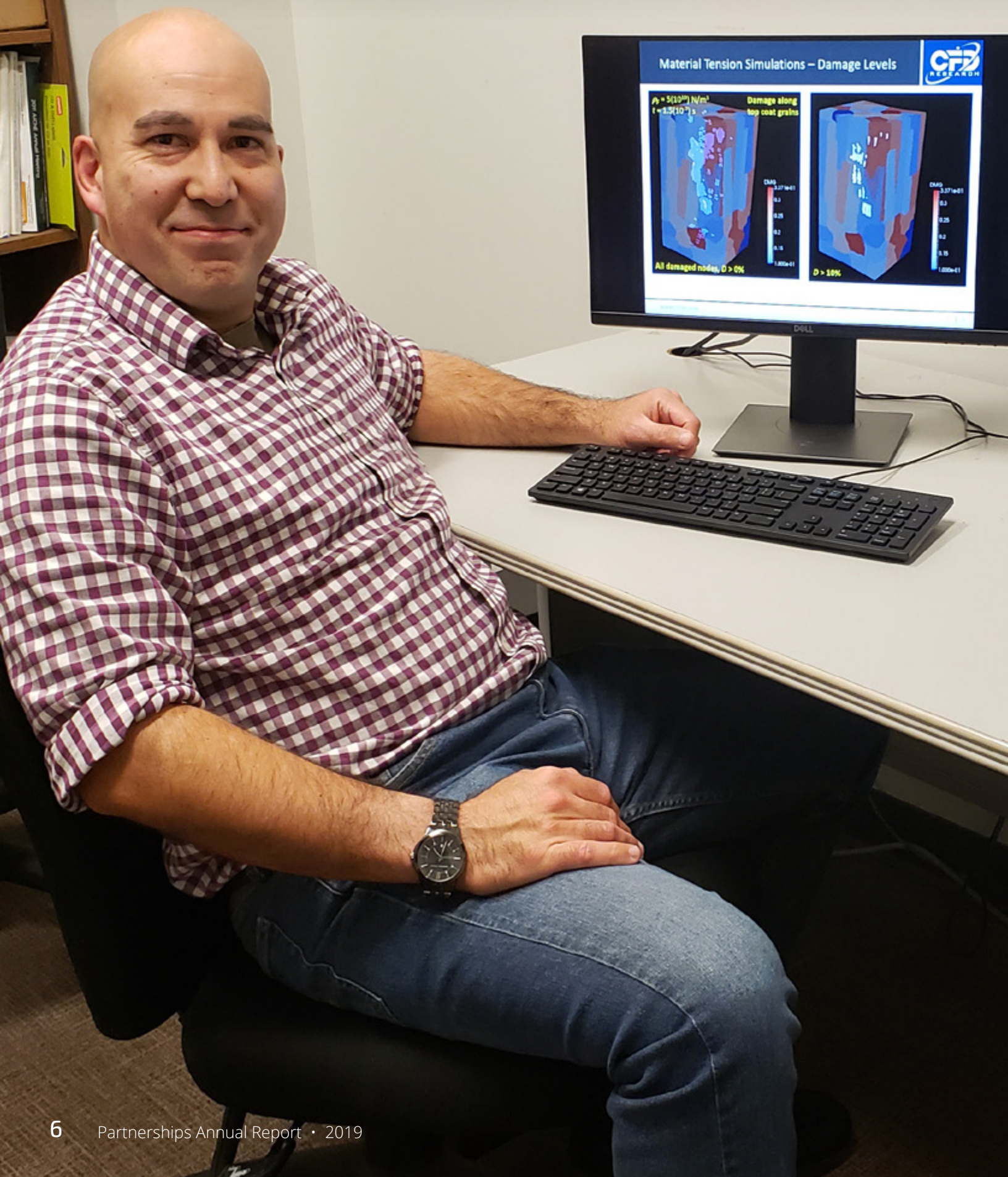
Currently ECG data is being used for health monitoring, but the new application being developed could result in improved security for any secure facility where other biometric security measures are impractical.

For Aquila, creating a new product, especially one that is the first of its kind, would result in economic impact for this small business and the state of New Mexico. This partnership will help move the technology from a concept to a tested prototype, a vital step on the path to a final product design.

PARTNERSHIP TYPE: Cooperative Research and Development Agreement (CRADA)

GOAL: Developing a new biometric security system based on electrocardiogram signatures

Aquila Field Engineer Hans Kayser, Director of Operations Mike Moran, and Mechanical Engineer Kaley Martinez demonstrate a device that measures heart rate with the ECG signature displayed on a tablet using the B-Secur application.



“The collaboration with Sandia has been very valuable in the analysis of damage processes in advanced coating systems. The peridynamics modeling approach, and the Emu software, provide unique capabilities for characterizing material response mechanisms under adverse operating conditions.”

— David Newsome
Principal Engineer
CFD Research

CFD Computational Materials Design Team Engineer David Newsome reviewing a slide showing a tension simulation applied to a microstructure model of an environmental barrier coating performed in Sandia's EMU peridynamics code.

Ceramic Jet Engine Coatings Analyzed to Improve Reliability

CHALLENGE

Jet engines and rocket motors produce very hot exhaust gases whose expansion creates mechanical power. Although many components of the engines are internally cooled, there are always surfaces that directly contact the hot gas. Many engine designs include ceramic coatings to protect these surfaces.

The drive toward greater engine efficiency and lighter weight means that newer engines use advanced materials and operate at higher temperatures than ever before. This creates a need to understand and improve the reliability of high-temperature ceramic coatings.

COLLABORATION

Under the sponsorship of the Air Force, Navy, and NASA, Sandia National Laboratories is partnering with [CFD Research](#) to develop a computational tool for analyzing the microscopic processes that affect the performance of these coatings. The team is applying Sandia's Emu peridynamic software code to the problem.

Peridynamics is a mathematical theory of mechanics used to model fractures in metals and components that was developed by Sandia scientist Stewart Silling. Emu is a computer code that implements the peridynamic model.

CFD Research, a company that specializes in engineering and innovative designs for aerospace, defense, and other industries, is licensing Emu, modifying it for the particular needs of this class of problems, and coupling it with their other fluid mechanics code. Silling worked together with CFD Research scientists to integrate the two codes to create the new software tool.

SOLUTION

CFD Research has improved the capabilities of the Emu code to model the complex processes at work as high temperature gas flows past the coating. These processes include heat conduction, mechanical pressure and drag, cracking, debonding of the coating, the impact of dust and debris, and the transport of chemical contaminants within the materials.

Engineers typically use finite element method (FEM)-based codes to analyze the mechanical response of aerospace structures. However, ceramic coatings, due to their complex structure and material properties, require a microscale approach to analyze their response to external stimuli. The Emu code from Sandia provides a number of mathematical models and material properties for this specialized application.

IMPACT

The new modeling capability that combines Emu with state-of-the-art fluid dynamics codes is being developed and delivered to the relevant U.S. government agencies. These innovative modeling tools will be applied to analyze the reliability and safety of new material coatings for engine components. Sandia's research also helps in the analysis of high velocity flight vehicles as part of its nuclear weapons mission.

PARTNERSHIP TYPE: License and Strategic Partnership Project (SPP)

GOAL: Creating new tools to help characterize the reliability of ceramic coatings in jet engine components, thereby supporting aircraft maintenance and minimizing downtime



“Our collaboration with Sandia through the HPC4Mtls program has provided Skyhaven with a greater understanding of the hydrogen generation process. Mass, energy, flow, and reaction rate modeling has aided in improving the design and performance of Skyhaven’s compact emergency hydrogen refueler for fuel cell vehicles.”

— Michael C. Kimble
President
Skyhaven Systems, LLC

■ Skyhaven Vice President Daniel Carr and Research Engineer Desiree Kettell holding a hydrogen refueler prototype.

Portable Hydrogen Refueler Extends Fuel Cell Vehicle Range

CHALLENGE

Zero emissions hydrogen fuel cell electric vehicles (FCEVs) have become more popular in recent years. But the lack of hydrogen fueling stations is causing consumers to have range anxiety, and is considered one of the main barriers to more widespread hydrogen FCEV adoption.

The DOE is funding efforts to design a compact emergency hydrogen refueler. This would help make hydrogen FCEVs a more attractive and reliable alternative to gasoline vehicles. The refueler needs to be economical and portable, providing enough hydrogen to reach the nearest fueling station, while being safe and easy for drivers to use.

COLLABORATION

[Skyhaven Systems](#) is working with Sandia National Laboratories to further develop their lightweight, compact emergency hydrogen refueler for fuel cell vehicles. This project is being funded by [High Performance Computing for Materials](#) (HPC4Mtls), a program which aims to utilize the high performance computing of DOE’s national laboratories to help industry develop new or improved materials. Under HPC4Mtls, selected projects have access to the labs’ HPC facilities, as well as the labs’ expertise in modeling, simulation, and data analysis.

Skyhaven had already begun developing their lithium hydride/water-based hydrogen refueler concept, but wanted to optimize the refueler to improve its performance. For this project, Sandia scientists are using their HPC expertise to develop a robust numerical model of the hydrogen refueler to increase conversion of source material to hydrogen, reduce operating temperature, and decrease the refueler’s size.

SOLUTION

The Skyhaven refueler contains a lithium hydride compound that when exposed to water kept in a separate reservoir releases hydrogen gas and lithium hydroxide. This refills the vehicle gas tank with enough hydrogen to travel up to 50 miles to a refueling station. This compact and lightweight product can be stored indefinitely in the vehicle trunk, giving the vehicle driver assurance that they have a hydrogen source in case they run out.

IMPACT

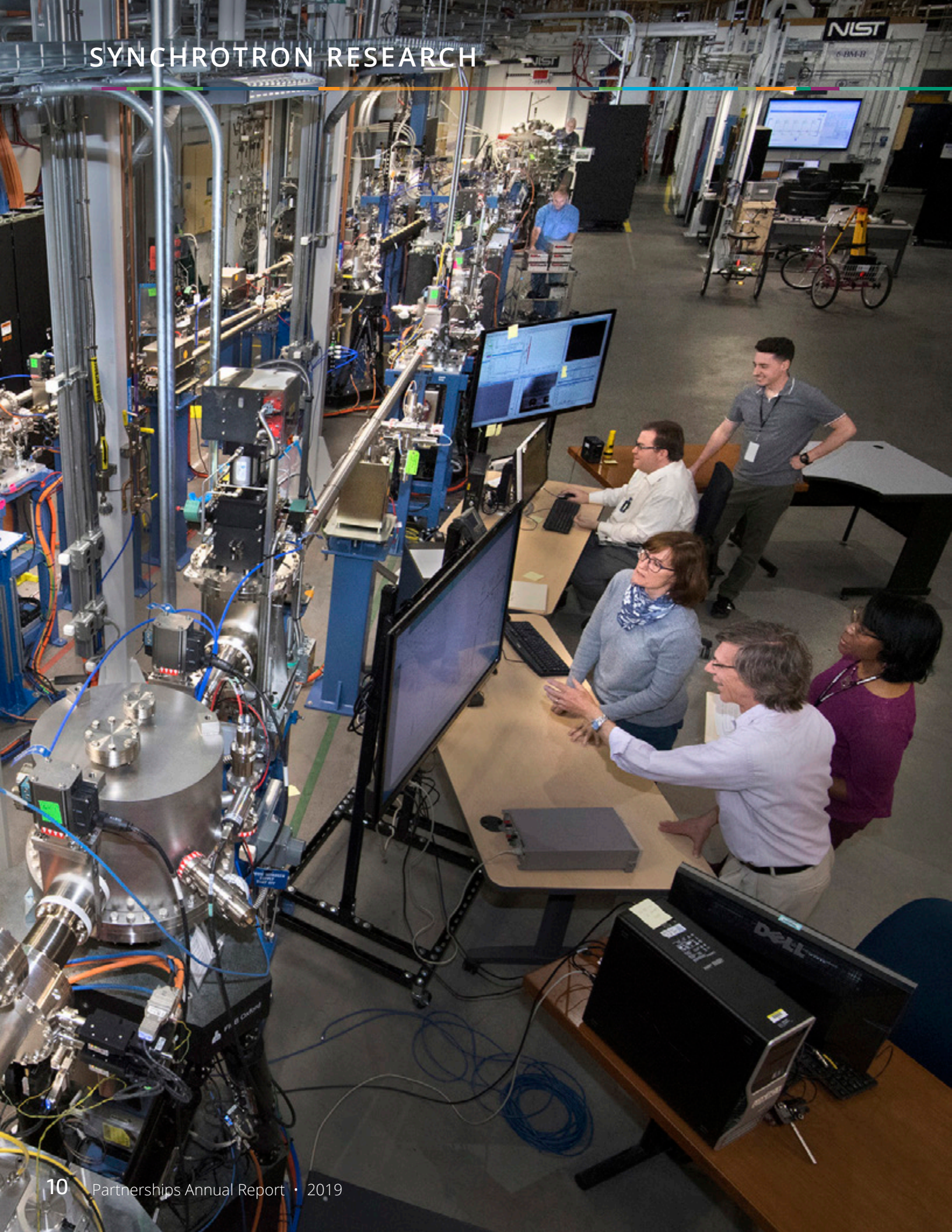
Offering this emergency hydrogen refueler to vehicle owners will help alleviate range anxiety, further helping to commercialize hydrogen fuel cell vehicles and the continuing commissioning of hydrogen refueling stations.

This project supports the nation’s energy strategy—helping to diversify America’s energy sector, reduce the dependence on foreign oil, and help reduce petroleum combustion emissions by accelerating the deployment of fuel cell vehicle technologies. The hydrogen refueler will greatly reduce barriers to market penetration by allowing hydrogen fuel cell vehicle users to have an extended driving range in case of emergency due to a lack of hydrogen refueling stations.

PARTNERSHIP TYPE: Cooperative Research and Development Agreement (CRADA)

GOAL: Creating a compact portable refueler to extend driving range and support commercialization of hydrogen fuel cell vehicles

SYNCHROTRON RESEARCH



“Technology transfer of the AXSIA process for automated multivariate data analysis developed at Sandia allows synthesis of the vast hyperspectral chemical imaging data sets acquired on our LARIAT imaging spectrometers into a single multi-component image to achieve a readily interpretable result.”

— Ed Principe

*President
Synchrotron Research, Inc.*

■ The NIST beamline team and the LARIAT MKII spectrometer which employs a 8.6 Tesla superconducting magnetic field to produce full-field 16 million pixel spectral images over an area up to 20x20 mm at a rate up to 600 images per hour, with nearly 100% transmission efficiency.

Faster Analysis of Hyperspectral Data to Expedite Materials Research

CHALLENGE

It can be difficult to discern subtle differences in complex data gathered from a hyperspectral imaging system like a synchrotron, a type of particle accelerator. One of the remaining obstacles to adopting these techniques for routine use is the challenge of reducing the vast quantities of raw spectral data to meaningful information.

The [National Synchrotron Light Source II](#) (NSLS-II) at Brookhaven National Laboratory is a user facility offering beamlines with x-ray, ultraviolet, and infrared light to academic and industrial users for scientific research in clean and affordable energy, high-temperature superconductivity, molecular electronics, and more.

[One of the beamlines](#) at NSLS-II is operated by the National Institute of Standards and Technology (NIST). [Synchrotron Research, Inc.](#) (SRI), a company which designs and manufactures analytical instrumentation, has been partnering with NIST for years to develop imaging systems for the beamlines. They have also been trying to find more efficient ways to automate data processing, making it as rapid and robust as possible.

COLLABORATION

SRI's Near Edge X-ray Absorption Fine Structure (NEXAFS) imaging spectrometers enable an array of important scientific investigations by NIST beamline users, including Sandia National Laboratories, which uses the beamline for materials research. When SRI President Ed Principe met Sandia scientist Tony Ohlhausen during work at the beamline, he learned about Sandia's Automated eXpert Spectral Image Analysis (AXSIA) software and realized this could help analyze the complex hyperspectral data sets.

SRI engaged with Sandia, licensed AXSIA, received some training, and is now modifying the code in order to implement it into the Large Area Rapid Imaging Analytical Tool (LARIAT) NEXAFS spectrometer beamline system and workflow.

SOLUTION

By combining the AXSIA software with the spectrometers on the beamline, SRI and NIST feel they are creating a far more powerful research tool and perhaps the most efficient electron spectrometer on an x-ray beamline.

AXSIA goes through the data automatically, recognizing small variations, and extracting the most relevant pieces with minimal user intervention. This functionality will enable a wide range of scientific investigations on the beamline instruments which may have previously been impractical.

IMPACT

Part of NIST's mission is to enhance the competitiveness of U.S. companies. Researchers from academia, industry, and national labs are beamline users. Once Sandia's AXSIA software is fully integrated, all researchers who run spectroscopy experiments on the NIST beamline with SRI spectrometers, including Sandia, will benefit from the enhanced system's better data processing abilities, aiding in data interpretation and helping to advance important research.

PARTNERSHIP TYPE: License

GOAL: Improving data analysis for the huge data sets gathered by experiments utilizing imaging spectrometers



“With this unique capability, Sandia and NREL are proud to be a part of the DOE effort to improve energy sector resilience. By using our joint expertise to address infrastructure vulnerabilities, we can help enable the development of a more secure and resilient energy grid.”

— Jessica Lau

*Project Manager
Strategic Energy
Analysis Center
National Renewable
Energy Laboratory*

Sandia Researchers Anya Castillo, Andrea Staid, and Ben Knueven looking over the latest simulation results run using a grid model and system data provided by NREL that show how the power grid might perform during a polar vortex event.

Energy Infrastructure Model to Improve Grid Resilience

CHALLENGE

Our nation depends on energy infrastructure for everything from banking and water distribution to telecommunications. But threats to these systems continue to grow and evolve. The reliable flow of energy is at risk from extreme weather, as well as cyber and physical attacks.

Aging infrastructure and changing threats are likely to increase the frequency of energy supply disruptions, while technological and population changes are increasing our dependence on these same supplies. That’s why there’s an urgent need to understand energy infrastructure vulnerabilities and develop mitigation strategies.

COLLABORATION

An ambitious effort led by the DOE, the [North American Energy Resilience Model](#) (NAERM) is a collaboration between eight DOE national laboratories and the government to develop a comprehensive resilience modeling system for North American energy sector infrastructure. While NAERM includes a number of DOE labs, Sandia National Laboratories is working most closely with the [National Renewable Energy Laboratory](#) (NREL) on this effort, each serving as a co-lead of the Threats, Economics, and Metrics efforts on NAERM.

NAERM will leverage and build upon national laboratory research capabilities. While past optimization modeling at Sandia has been focused on reliability for utilities, what is required now is modeling focused on resilience in large-scale disasters. NREL has developed national-scale models of electric infrastructure. Sandia is using its experience in solving large scale optimization problems along with NREL’s models and data to assess threats to the nation’s energy infrastructure.

SOLUTION

NAERM will advance existing capabilities to model, simulate, and assess the behavior of electric power systems, as well as dependencies on natural gas, and other critical energy infrastructures. A resilient system is better able to anticipate, withstand, and recover from disasters. Creating a Resilient Operations Model (ROM) will help increase situational awareness and minimize the impact of threats.

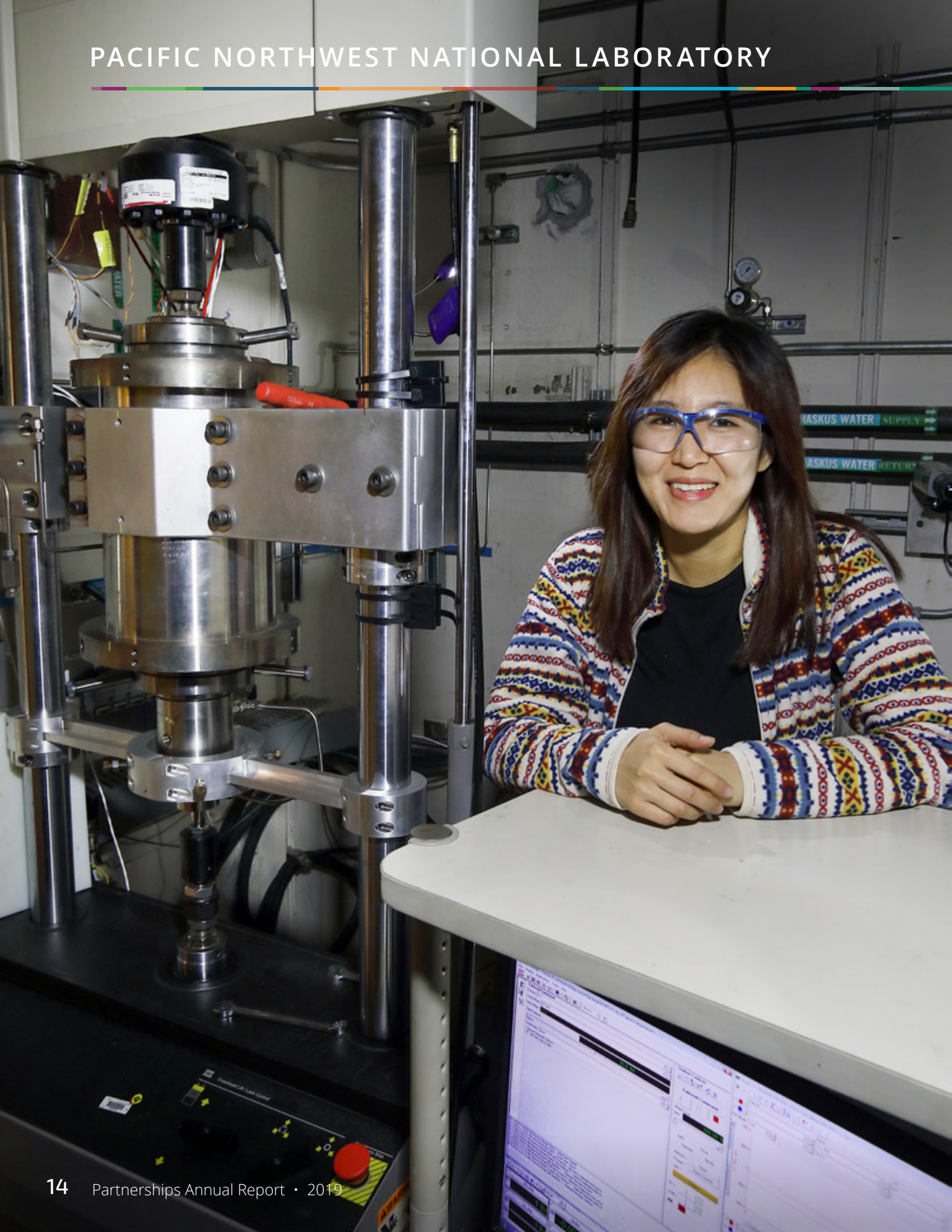
The ROM will represent power system generators, transmission lines, and other infrastructure. With it, disaster situations can be better anticipated, vulnerabilities assessed, and responses planned. Future work will incorporate real-time status updates from infrastructure such as generators and pipelines, giving an even better picture of the system’s current state and aiding in decision-making.

IMPACT

The NAERM capability will be a first-of-its-kind globally and will improve energy sector resilience for the well-being of our citizens and national security. Greater awareness of vulnerabilities will allow for improved planning and mitigation strategies for energy infrastructure. With resilience built into the system, industry and communities will be better prepared to deal with disasters and bounce back.

PARTNERSHIP TYPE: *Collaborative Research*

GOAL: *Being prepared to respond to natural and adversarial events to ensure reliable and resilient energy delivery across the U.S.*



“Materials scientists at Sandia and PNNL are the foundation for the experimental studies within this consortium. We’re leveraging our labs’ high-performance computational capabilities to study fundamental hydrogen-materials interactions.”

— Kevin Simmons

Senior Research Scientist
Pacific Northwest National
Laboratory

■ Former Sandia Post-doc Eun Ju Song led an effort to evaluate fracture resistance of pipeline steel welds in high-pressure hydrogen using unique high-pressure capabilities in Sandia’s [Hydrogen Effects on Materials Laboratory](#).

Hydrogen Storage Materials Studied to Enhance Reliability

CHALLENGE

Hydrogen is one of the most abundant elements in the universe and an important industrial chemical and fuel. Key stakeholders in both government and industry are leading R&D to enable new, innovative applications for hydrogen, such as iron refining, backup power, and fuel cell heavy-duty vehicles. A key focus of this R&D is the development of low-cost infrastructure to enable hydrogen technologies.

However, exposure to hydrogen can embrittle structural materials and reduce the reliability of infrastructure. “Materials compatibility” with hydrogen is a key consideration when developing hydrogen infrastructure and is often driven by microstructural features that can also influence material cost. To enable the use of lower cost materials, scientists seek a more complete understanding of how hydrogen interacts with materials at both the atomistic and engineering scale. This will enable them to better design materials to mitigate hydrogen-induced damage and lower the cost of hydrogen technologies and next-generation energy infrastructure.

COLLABORATION

The [Hydrogen Materials Compatibility Consortium](#) (H-Mat) focuses on the effects of hydrogen on the properties of polymers and metals used in hydrogen infrastructure and storage. Researchers at Sandia National Laboratories and [Pacific Northwest National Laboratory](#) (PNNL) are leading the collaborative effort, which also includes Oak Ridge National Laboratory (ORNL), Savannah River National Laboratory (SRNL), and Argonne National Laboratory (ANL).

H-Mat activities leverage the advanced computational capabilities, unique experimental facilities, and scientific expertise at the national laboratories. Researchers at Sandia, led by Chris San Marchi, are studying the behavior of metals and polymers while exposed to high-pressure hydrogen environments using unique equipment at the campus in Livermore, CA, while the teams at PNNL, headed by Kevin Simmons, are leading the characterization and experimental studies of cracking and degradation in polymers.

SOLUTION

Because of the small size and mobility of hydrogen atoms in materials, hydrogen is difficult to observe. In order to improve fundamental understanding of the basic physical interaction of hydrogen with materials, researchers are integrating innovative computational and experimental activities. One technique is to use model materials systems and computational simulation to study hydrogen-materials interactions at the micron scale and extrapolate the behaviors to engineering performance at the centimeter scale.

IMPACT

This program addresses fundamental science questions with the primary aim of providing engineering impact. By learning more about the behavior of materials in the presence of hydrogen, more reliable and lower cost materials can be engineered. Sandia and PNNL’s leadership in H-Mat supports DOE’s H2@Scale initiative to advance affordable hydrogen production, transport, storage, and utilization across diverse energy sectors.

PARTNERSHIP TYPE: Collaborative Research supported by the DOE’s Fuel Cell Technologies Office in support of the H2@Scale initiative

GOAL: Improving the reliability of hydrogen infrastructure materials to enable large scale use of hydrogen as an energy carrier

Sandia and UNM conduct research in a number of collaboration focus areas within their Sandia Academic Alliance (SAA) partnership including quantum information science, extreme environments, cyber physical security, autonomous systems, artificial intelligence/machine learning, nuclear engineering, nano/micro/optical devices, energy/water/materials, and HPC systems/algorithms.

“We wouldn’t have been able to do the radiological characterization without Sandia personnel and expertise. Without this information the benchmark would be incomplete.”

— Robert Busch

*Emeritus Principal Lecturer,
Chief Reactor Supervisor
Department of Nuclear
Engineering
University of New Mexico*

Nuclear Criticality Benchmark Development and Safety Training

CHALLENGE

Current nuclear fuel uses a maximum of 5% enriched uranium. To better utilize uranium fuel and provide for smaller nuclear reactors, newer reactors are working with up to 20% enrichments, or U(20). However, there is very little documented experimental data available for the region between U(5) and U(20) to provide for the validation of computer models, so there is a need in the nuclear criticality safety (NCS) community to develop international benchmarks.

COLLABORATION

Sandia National Laboratories and the [University of New Mexico](#) (UNM) are partners in the SAA Program, an initiative Sandia has formed with five universities to promote collaborative research and attract top talent to work on tough problems. A new CRADA is allowing the partners to team up on projects to bolster national security and advance science and engineering.

For the first project under the new CRADA, Sandia and UNM worked together to characterize U(20). UNM has an AGN-201 research reactor which uses this enriched fuel. Sandia had the necessary isotopic measurement capabilities and was able to deploy this expertise to UNM. The team included individuals from UNM and Sandia, as well as from [BWX Technologies, Inc.](#), Sandia Field Office (NNSA/DOE), [Oak Ridge National Laboratory](#) (ORNL), and the [DOE Nuclear Criticality Safety Program](#).

SOLUTION

Physical measurements and radiological characterization of the U(20) fuel were done to provide information suitable for benchmarks and validation efforts with higher uranium enrichments. The work involved complete disassembly of the UNM nuclear reactor, radiation measurements of the removed nuclear fuel, and the reassembly of the reactor.

One benefit of the project was that Sandians were able to train UNM personnel on the instrumentation used to perform the measurements, and aid them in the acquisition of similar equipment for future projects.


IMPACT

Ultimately, results from the testing of UNM’s reactor will be used to support development of benchmarks for the Nuclear Energy Agency’s [International Handbook of Evaluated Criticality Safety Benchmark Experiments](#), which is used to validate nuclear data. The project results will also support a recently funded feasibility study for use of spare AGN-201 fuel plates as an NCS training tool at ORNL.

Sandia’s NCS program was also able to use this as a professional training and development activity for newly qualified and in-training individuals. Another result was that Sandia donated surplus radiation measurement equipment to UNM for future research and training activities. Looking ahead, the umbrella CRADA will be used for future collaborations between Sandia and UNM to tackle issues important to national security.

PARTNERSHIP TYPE: *Umbrella Cooperative Research and Development Agreement (CRADA) and Sandia Academic Alliance (SAA)*

GOAL: *Developing a high-fidelity benchmark experiment supporting the validation of software used in nuclear design and safety analysis*

 **BWX Technologies**
Senior Advisory Engineer
Larry Wetzel surrounded
by the disassembled
nuclear reactor parts.
Top shelf: fuel disks and
thermal fuse; Bottom
shelf: control rod guide
tubes, reflector plug
and liners, baffle
plates, core tank,
and general pieces.

“The collaboration of JBEI and Aemetis has resulted in an efficient combination of theoretical ideas and operational realities to create a commercially exciting new process for biofuels production.”

— Eric McAfee
Chairman/CEO
Aemetis, Inc.

Aemetis' production facility in Keyes, CA, which produces 65 million gallons of ethanol per year.

Large-Scale Biofuel Production from Biomass Explored

CHALLENGE

Corn is being used to make the biofuel ethanol but what if biofuels could be made from waste? Biomass such as dead trees or plant material from non-food crops could be a huge source of biofuel feedstock. In the U.S. there is already about a billion tons of agricultural non-food biowaste that could be used to make fuel each year. In addition, the development of dedicated bioenergy crops can add to the available feedstock.

COLLABORATION

The [Joint BioEnergy Institute](#) (JBEI) is a DOE Bioenergy Research Center in California dedicated to developing advanced biofuels—liquid fuels derived from the solar energy stored in plant biomass. Sandia National Laboratories is one of the research participants in JBEI, which has national laboratory, academic, and industry partners. [Aemetis](#), an advanced renewable fuels and biochemicals company based in California with multiple biofuel production facilities, is working with JBEI on a project to advance new methods for creating biofuels.

The goal is to scale up technologies that can produce biofuels and bioproducts in an integrated process that will create gasoline, diesel, and jet fuel replacements that are competitively priced and will transform the bioenergy marketplace. At the same time, bioproducts that can replace petroleum-derived products such as plastics and chemicals will be produced.



Lawrence Berkeley National Laboratory Research Scientist Eric Sundstrom with the lab-scale 2-liter reactor producing sugars from forest and agricultural wood.

SOLUTION

The vision of JBEI is that biomass can be converted into economically-viable, carbon-neutral, specialty biofuels, all of the organic chemicals currently derived from petroleum, and many other useful bioproducts that cannot be efficiently produced from petroleum.

With funding from the California Energy Commission, Aemetis is working with JBEI to demonstrate a new ionic liquid pretreatment and conversion technology to create biofuels from woody agricultural and forest residues found in California. The project aims to produce both ethanol and a new fuel developed at JBEI, isopentenol, which can be used as a drop-in replacement for gasoline.

Aemetis has experience in producing biofuels at a commercial scale and will be able to help JBEI move a small-scale, lab-demonstrated process to an economically viable, large-scale industrial process. The research will focus on studying bioenergy crops to be used for biofuels, and more efficient methods of converting the biomass into fuels in order to extract the most energy possible.

IMPACT

JBEI's approach aligns with and supports the DOE and California strategic plans for renewable energy, bioenergy, mission innovation, and sustainability. Supporting a sustainable domestic plant biomass biofuel and bioproducts industry also ties to U.S. efforts to ensure future energy security, lower greenhouse gases to mitigate climate impacts, and diversify the range of available biobased products.

PARTNERSHIP TYPE: Cooperative Research and Development Agreement (CRADA)

GOAL: Finding new, efficient, economically viable ways to create biofuels from biomass at large scales

Electric Cables Used in Nuclear Power Plants Tested for Safety



The Gamma Irradiation Facility (GIF) at Sandia National Laboratories simulates nuclear radiation environments for materials and component testing. The GIF can house a wide variety of gamma irradiation experiments with various test configurations and at different dose rate levels. Although it is designed to irradiate objects as small as bacteria and as large as an M1 Abrams tank, it often tests electronic components, equipment, and material samples.

The [National Institute of Standards and Technology](#) (NIST) is utilizing the specialized facilities and expertise of GIF scientists to perform aging experiments on electric cabling used in nuclear power plants. These older plants are licensed by the Nuclear Regulatory Commission (NRC), and with many licenses about to expire, license renewals are required. The NRC asked NIST to test several types of cables used in plants to ensure their safe performance for extended periods of time.

For this important testing, NIST chose the GIF. Unlike many other facilities, the GIF was able to meet their requirements for low-dose rate irradiation over an extended period of time. Stephanie Watson and her team from NIST worked closely with GIF scientists Don Hanson and Maryla Wasiolek to design a unique environmental chamber to use for testing the cables.

This almost two-year experiment, the longest ever conducted at the GIF, will simulate 80 years of exposure to low-dose rate radiation to replicate cable exposures found in the nuclear power plants. Every two months cable samples are removed from the chamber and tested, then placed back in the chamber to continue the experiment.

Ensuring the safety of components used in nuclear power plants is just one example of how the GIF helps perform testing critical for national security.

Sandia Scientist Maryla Wasiolek operating a gamma irradiation cell where the NIST cable irradiation experiment takes place.

To learn more about the Gamma Irradiation Facility, visit www.sandia.gov/research/facilities/gamma_irradiation_facility.html



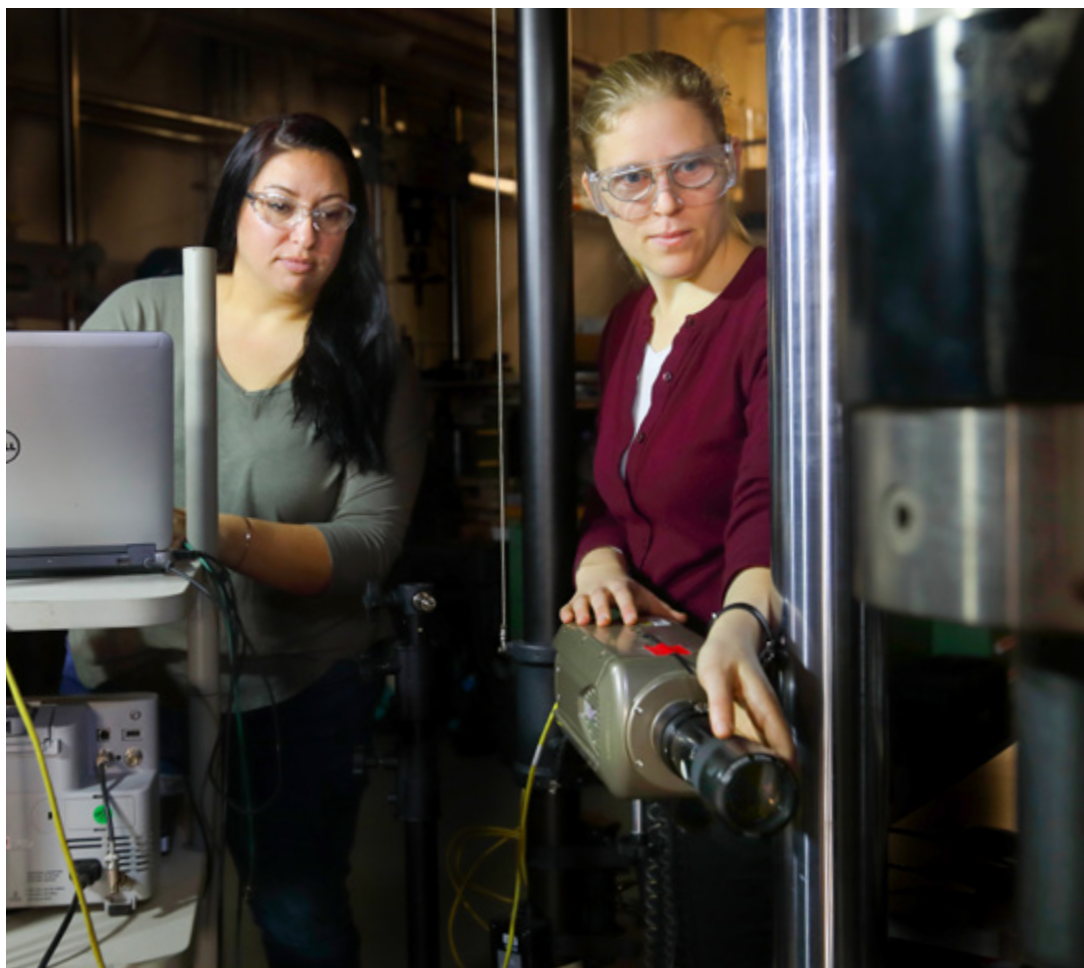
Modeling Tool Allows Faster Introduction of New Material Systems

The Mechanical Test and Evaluation Facility at Sandia National Laboratories, California, conducts experimental research and develops diagnostics to study the mechanical behavior of materials including metals, structural foams, ceramics, polymers, and composites. Work for DOE customers includes material characterization, fracture and failure mechanics, validation of massively parallel engineering mechanics computer codes, and mechanical testing of prototype hardware. As a Sandia Technology Deployment Center, the facility is also available for use by U.S. industry, universities, academia, and others.

M4 Engineering, an aerospace and mechanical engineering analysis and consulting company, partnered with Sandia to create an advanced modeling tool for adhesive bonds that improves analysis and reduces testing, allowing for faster introduction of new material systems. The recently concluded R&D project began in 2012 as a Small Business Technology Transfer partnership under Navy Funding. M4 and Sandia developed a software tool to predict the deformation and failure of adhesively bonded joints by extending a polymer model previously developed by Sandia. The software interfaces with the commercial code Abaqus.

In order to confirm the accuracy of the new computer modeling tool, multiple adhesives were characterized on metallic and composite substrates and tested for fracture toughness at different thicknesses and temperatures in the Mechanical Test and Evaluation Facility. This helped developers validate the accuracy of their computer models with real-world results.

This Abaqus-based capability reveals the response of bonded joints for a broad range of mechanical and environmental loading conditions to give higher operational reliability. Beyond direct employment by the Naval Air Systems Command (NAVAIR)-China Lake sponsor, the tool is ready for adoption throughout other DoD labs, as well as by their prime contractors in the aerospace and mechanical engineering fields.



Sandia Technologist Danielle Oteri and Engineer Kimberley Mac Donald setting up a camera to record images used for diagnostic measurements of specimen response during mechanical loading.

To learn more about the Mechanical Test and Evaluation Facility and other Technology Deployment Centers, visit https://www.sandia.gov/research/facilities/technology_deployment_centers/



New Companies in the Park Support Sandia Missions



The Sandia Science & Technology Park (SS&TP) continues to grow and create economic impact in the region. The Park added four new companies in FY19 with ties to Sandia National Laboratories' missions.


[Dynetics Technical Solutions](#) (DTS) provides expertise to a variety of critical infrastructure sectors. The company is locally collaborating with Sandia on development and production of hypersonic glide bodies for the Army and Navy. The system will be a part of an integrated Army hypersonic weapon prototype that will deliver residual combat capability to the warfighter. DTS is a wholly owned subsidiary of Dynetics, a 45-year-old aerospace and defense contractor.

[Excelligent](#) is a project management and control consulting firm that is knowledgeable in systems engineering and production processes. The company, a Small, Hispanic-owned, and Veteran-owned business, provides integrated management solutions to federal customers and contractors, including NNSA Defense Programs. Excelligent has contracts with Sandia to provide project management consulting services to support major modernization programs.

[TechSource](#) is a science and engineering consultancy specializing in program management and technical delivery of nuclear and high-technology projects. The company has contracts to evaluate and improve critical infrastructure and security effectiveness for a variety of Sandia organizations, including a significant pulsed-power reworking of the Saturn X-ray machine. TechSource is headquartered in Los Alamos, NM, and employs over 500 senior-level scientists, engineers, and industry leaders.

[X-Bow Systems](#) is a small launch vehicle provider and technology development company.

The SS&TP is a 300+ acre technology community. The Park's location adjacent to Sandia makes it easy for companies to collaborate with the Labs on a broad assortment of technologies, products, and services and gives them access to world-class facilities, scientists, and engineers.

 Aerial view of
the SS&TP.

The New Mexico
State House and
Senate recognized
the SS&TP for 20
years of economic
growth with joint
memorials.

To learn more about the
SS&TP, visit www.sstp.org



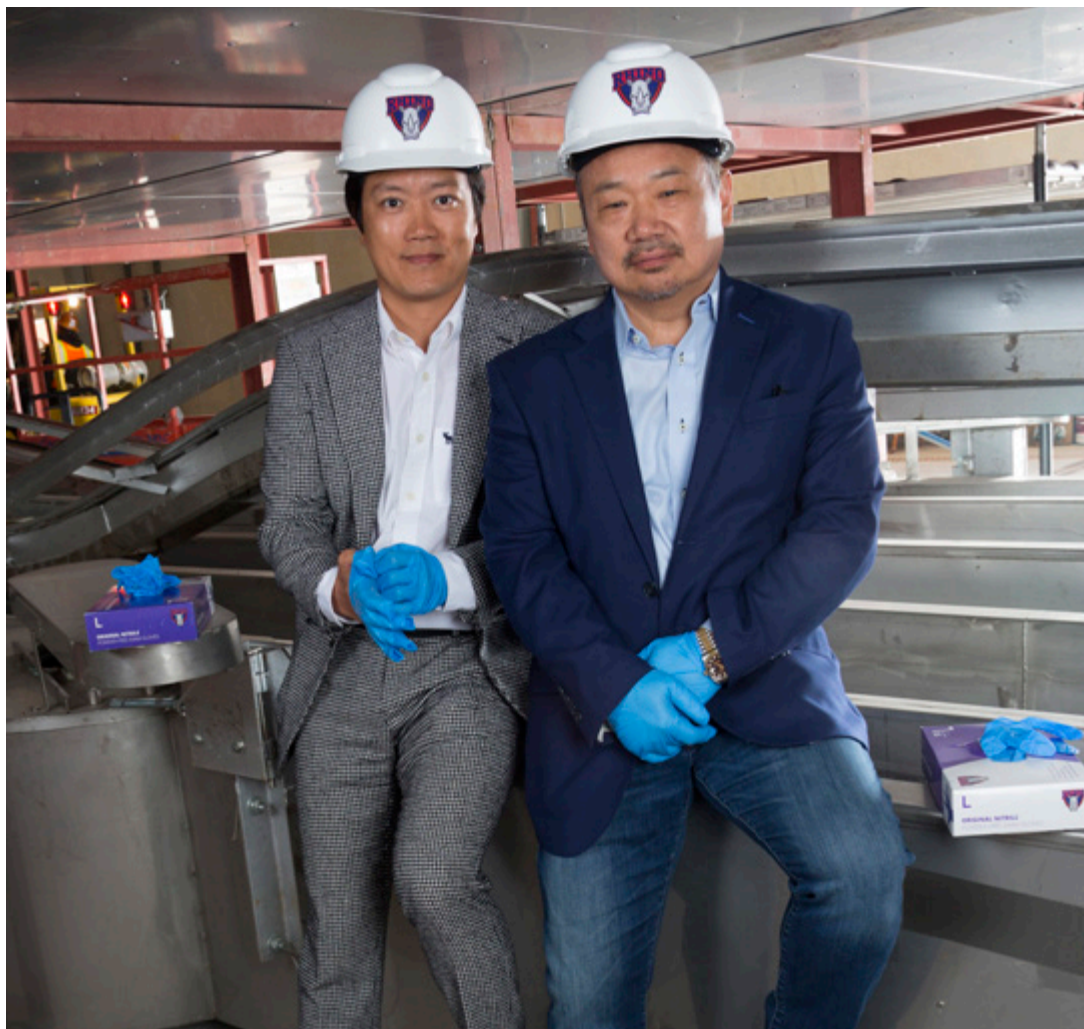
Cutting Water Use Helps Glove Manufacturer Grow

Made from synthetic rubber, nitrile gloves are a proven alternative to latex, which causes allergic reactions in some people. Nitrile gloves, with their strong chemical and puncture resistance, are widely used in medical, scientific, and other settings that require disposable gloves.

Mark Lee and his partner DJ Yoon established [Rhino Health](#) to build a nitrile glove factory in the U.S. They wanted to build in New Mexico near Gallup, but realized that manufacturing the gloves would require a lot of water of a certain quality. Through the New Mexico Small Business Assistance (NMSBA) Program, they were connected with Patrick Brady of Sandia National Laboratories. Brady's decades of work on water desalination as part of Sandia's mission to improve the nation's water security and make U.S. industry less vulnerable to water stresses gave him the expertise needed to aid Rhino.

Through two NMSBA projects, Brady and the Rhino team analyzed the water quality and determined methods to reduce factory water consumption by 22% to 30%. This means Rhino can manufacture more gloves per gallon of water. They also worked on getting the factory to zero liquid discharge, helping the company greatly expand operations without discharging more wastewater. This is made possible by water desalination techniques and water recycling.

The results of the NMSBA projects have given Lee the confidence to move forward. In its first phase of operations, Rhino has already installed over \$5 million of new production equipment. They have begun producing nitrile gloves and have about 35 employees, with more being added. Rhino anticipates investing more than \$45 million, part of which will go toward building an additional 110,000-150,000-square-foot manufacturing and warehouse facility and creating up to 350 new jobs.



■ Rhino Health VP and COO DJ Yoon and President and CEO Mark Lee at their manufacturing facility.

To learn more about NMSBA, visit www.NMSBAprogram.org.



Water-Go-Round Moves Hydrogen Fuel Cells to Commercial Waters



Fuel cells turn hydrogen into electricity while producing no exhaust other than clean water. But until an inquiry from a San Francisco ferry boat operator in 2014, scientists in the U.S. had not yet studied how to apply hydrogen fuel cells to ships.

As part of its energy security and resiliency mission, Sandia National Laboratories runs the Hydrogen and Fuel Cells (H2FC) research program, which for the past 15 years has investigated the feasibility of using hydrogen fuel cells in a variety of applications. Acting on the inquiry they received, Sandia scientists started investigating the use of hydrogen on board vessels.

Joe Pratt had been working at Sandia on commercialization of hydrogen and fuel cells for vehicles, power generators, even for power on board airplanes. Pratt and fellow Sandia scientist Lennie Klebanoff applied the same market-driven approach on a variety of successful maritime projects.

After seeing that hydrogen fuel cell vessels were possible, and commercially viable, Pratt left Sandia at the beginning of 2018 to start [Golden Gate Zero Emission Marine](#) (GGZEM). He utilized Sandia's Entrepreneurial Separation to Transfer Technology (ESTT) program. 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.

Now, among other projects, GGZEM is constructing the [Water-Go-Round](#), a 70-foot ferry planned for launch in San Francisco Bay in 2020. It is the first fuel-cell vessel in the western hemisphere and the first commercial fuel-cell ferry in the world. Pratt is also a Partner at Zero Emission Advisors, assisting the deployment of capital into the worldwide hydrogen energy market. He and Klebanoff continue to collaborate regarding hydrogen safety and regulatory compliance.

**GGZEM CEO and CTO
Joe Pratt and Sandia
Scientist Lennie
Klebanoff.**

New Programming Added to Entrepreneurial Events

The [Entrepreneur Exploration](#) (EEx) program is focused on linking Sandia National Laboratories' principal investigators with entrepreneurial opportunities and resources provided by a multitude of partners. It is designed to invigorate an entrepreneurial culture at the Labs and help fulfill Sandia's technology transfer mission. This program inspires researchers to either go into the business world or develop that innovative mindset while at Sandia. This year, EEx held 20 events which included trainings, webinars, and two new programs, Idea Sprint and Studio G.

Idea Sprint, an intensive, two-day training program for Sandia researchers, was designed by the University of New Mexico's [Innovation Academy](#), which has experience providing training programs for students interested in technology transfer and commercialization. Idea Sprint covered a broad range of topics, including design-thinking, prototyping, business model canvas, and pitching ideas. Researchers worked to model, test and develop opportunities for new ventures. Some of the participants came in with Sandia intellectual property (IP), some had ideas for businesses unrelated to their work, and others had ideas for internal, organizational change.

[Studio G](#) is a virtual business accelerator developed by New Mexico State University to help launch and scale new businesses. Through Studio G, the ten Sandia post-docs and students who took part had access to online curriculum and resources, as well as a vast network of advisors, including entrepreneurs, investors, IP lawyers, accountants, designers, and manufacturing experts.

EEx is the flagship program for the Center for Collaboration and Commercialization (C3). C3 serves as a "front door" to Sandia and is designed to strengthen partnerships, technology transfer, and ties to the community.

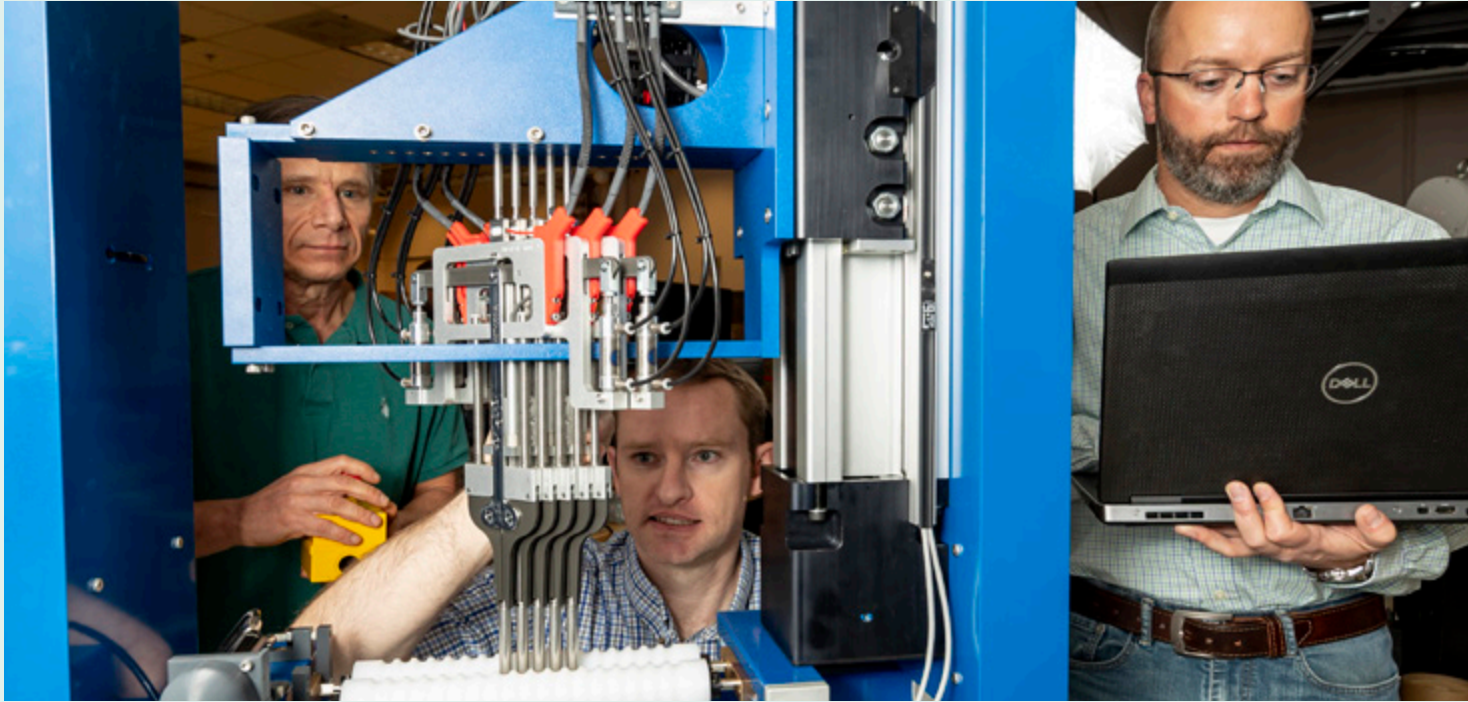


Idea Sprint participants working on projects.

To learn more about C3, visit www.C3abq.com



Robotic Technologies Could Help Reduce Spent Fuel Disposal Cost



Sandia National Laboratories is working with [NAC International](#), a provider of nuclear fuel cycle technology, to develop a robotic system for consolidating spent nuclear fuel (SNF) assemblies. The goal is to improve the efficiency and reduce the cost of permanent disposal of commercial SNF. Currently, about 30,000 metric tons of commercial SNF is in on-site dry storage at more than 60 locations around the U.S., with inventory rapidly increasing.

This SNF is stored in large, high-capacity dual-purpose canisters (DPCs). While DPCs are efficient for dry storage they are not designed or licensed for repository disposal. The inability to dispose of DPCs carries an estimated legal liability of \$34 billion from the federal government's "Judgment Fund," and could require repackaging at a cost of about \$20 billion.

A recently completed two-year DOE Technology Commercialization Fund (TCF) project focused on maturing and demonstrating Sandia's robotic technologies that could be used to transfer fuel rods into consolidated rod canisters (CRCs). Energy-related TCF projects pair lab researchers with industry partners who are evaluating lab-developed technologies that fit their business models.

The end product of the Sandia-TCF project was a robotic gripper apparatus with the capability to extract surrogate fuel rods from a representative fuel assembly. This demonstrated low-force robotic extraction capability, which could subsequently interface with a CRC. The CRCs are smaller, low-cost canisters that will meet storage, transportation, and disposal licensing requirements and can provide an option for the DOE to reduce some of the \$54 billion in potential costs and liabilities.

Sandia was recently awarded four new TCF projects. Work on TCF projects helps federally funded Sandia research move towards commercial application through partnerships with the private sector.

Sandia Product Design Engineer Bob Dedig, CAD Technologist Jacob Baker, and Mechanical Engineer Scott Rose in Sandia's Rapid Prototyping Robotics Lab demonstrating successful proof-of-concept for extracting surrogate fuel rods from a representative spent nuclear fuel assembly.

To learn more about TCF, visit <http://www.energy.gov/technologytransitions/services/technology-commercialization-fund>

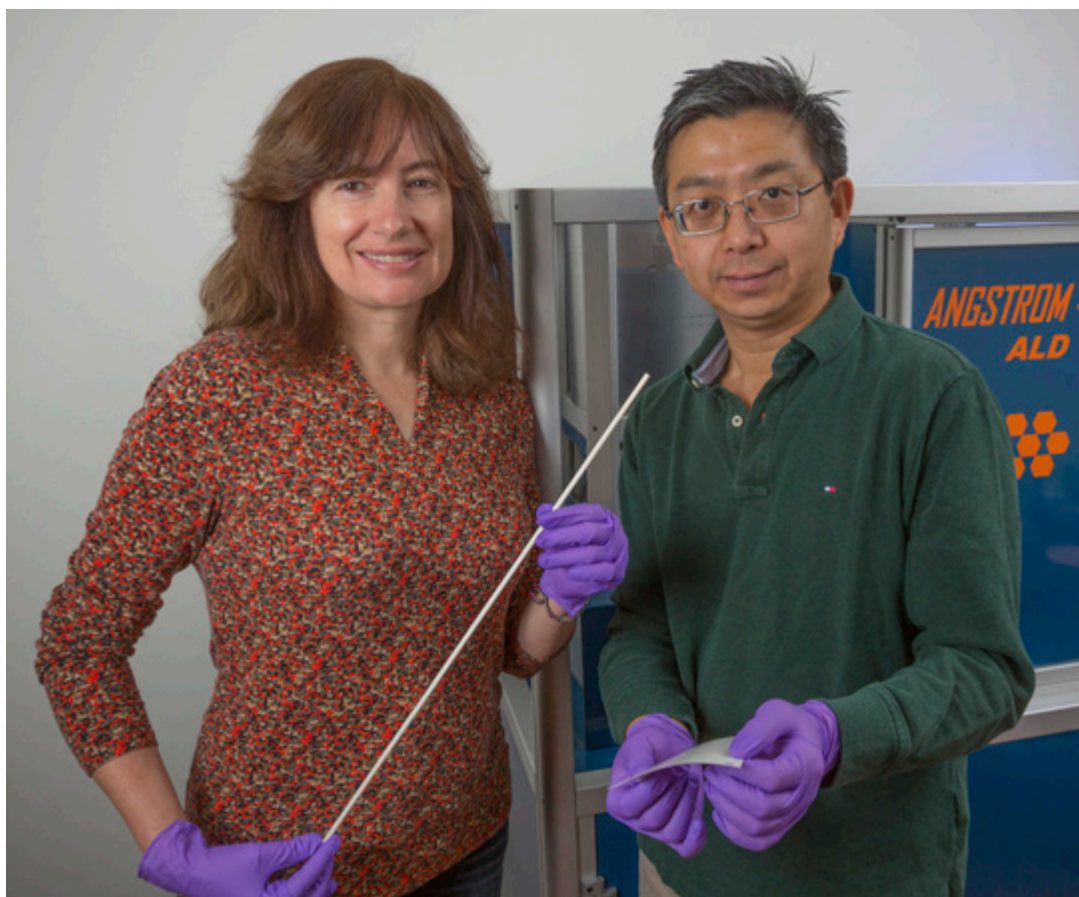


Sandia Teams Explore Their Technologies' Commercial Possibilities

Sandia National Laboratories had four teams selected to take part in the DOE's Energy I-Corps Cohort 10. This two-month program pairs national laboratory researchers with industry mentors. Researchers work with their industry mentors to identify viable market pathways for their energy and national security technologies.

- The CO₂-Memzyme is a bio-inspired membrane loaded with enzymes for filtering CO₂ from gas mixtures. Due to its exceptional performance and low capital cost, the membrane is projected to separate nearly pure CO₂ from power plant emissions at less than half the cost of conventional technology, making carbon capture, storage, and utilization profitable while restoring our climate.
- Industry can't scale algae production for bioenergy and biomaterials cost effectively, while it's almost impossible to stop algae from growing where it's not wanted. [GreenRM](#) is a technology to produce algal biomass from compromised surface waters. A similar concept has already been shown to effectively bioremediate waters, but GreenRM couples remediation with biomass production.
- Enduring Advantage creates electrodeposited nanocrystalline material coatings for electrical contacts. These [alloys](#) are the most wear resistant of any metal, hard, corrosion resistant, and conductive. They can also be electrodeposited on complex geometries at variable thicknesses, enabling new applications, thinner coatings with improved performance, and decreased cost.
- Digital high-speed camera technology has made it commonplace to record images down to the microsecond. To capture events at faster timescales, options are limited. This leaves the visualization of many events beyond reach for most researchers. Sandia's [Ultra-Fast X-Ray Imager](#) (UXI) system can provide an affordable, high performance, solid state imaging solution in a single sensor.

After participating in Energy I-Corps, Sandia researchers have a better understanding of the technology maturation process, supporting the Labs' technology transfer mission.



Sandia Researcher Susan Rempe and UNM Research Associate Professor Ying-Bing Jiang, co-founders of the start-up company [Memzyme, LLC](#), show flexible and rigid supporting materials for scaling up the CO₂ capture technology.


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



Entrepreneurs Analyze Sandia Technologies for Potential Startups



Sandia National Laboratories took part in the 2019 FedTech Startup Studio. FedTech pairs intellectual property (IP) from federal research agencies with aspiring entrepreneurs interested in starting new ventures in a low-risk environment. During the two-month accelerator, teams work closely with inventors and mentors and are taken through modules on lean startup, business models, product development, customer discovery, IP and licensing, funding strategies for spinning out R&D, pitch skills, and more.

 Sandia Researcher
Edward Jimenez in the
Micro X-Ray CT Lab.

Three teams investigating Sandia technologies were part of the 2019 cohort. Each included a Sandia inventor and/or Principal Investigator (PI), along with industry mentors and entrepreneurs.

- The [High-Fidelity Adaptive Deception & Emulation System](#) (HADES) team came up with a concept called “Github for DoD.” This approach would allow defense-entrepreneurs to field test products in realistic environments using emulotics, a holistic approach to cyber system emulation and analytics, and ensure compliance with federal cybersecurity protocols.
- A second team was looking at Hyperspectral X-Ray CT Scanning Technology for National Security Applications. They identified several potential markets for this technology and decided to focus on transportation security. They believe that this IP could be integrated into TSA and Homeland Security programs and deployed primarily at domestic airports.
- Customer discovery for the Interconnect System with Friction Fit (ISFF) Backshell team found a potential market for this electrical cable interconnect system with design engineers working in the defense industry and with integrated components makers/assemblers.

The FedTech experience was largely positive for the Sandia PIs who benefited from a professional development experience. In addition, all three startup teams have expressed an interest in pursuing partnership opportunities with Sandia.

To learn more about FedTech,
visit www.fedtech.io/



Online Tools for Finding Experts, Technology, and Facilities Expand

The DOE's Lab Partnering Service (LPS) is a suite of online applications providing access to leading experts, projects, and patents from across the DOE national laboratories in order to promote technology transfer. It provides a conduit between innovators and potential partners.

LPS applications include Technology Summaries, browsable business-friendly descriptions of technologies available for licensing; and Visual Patent Search, a tool that enables a unique way to search DOE-funded patents and patent applications. Sandia National Laboratories has expanded its presence in these tools to 108 technology summaries and 2477 patents or patent applications.

In FY19 two new features were added—[Success Stories](#), examples of successful technology transfer; and a [Facilities Search Tool](#), which lets users search for lab facilities available for use, including those at Sandia. Sandia is leading development of nano/micro and grid modernization modules, which will add more detailed information on facilities serving those specialties.

[Expert Search](#), a selection of lab-identified experts across hot technology areas has continued to grow. Website visitors can search by technical market sector or keywords to find experts with the knowledge they need. Sandia added nine new experts in FY19, all with expertise in artificial intelligence and machine learning. Brad Aimone, Warren Davis IV, Emily Donahue, Raga Krishnakumar, Kiran Lakkaraju, Matthew Marinella, Matthew Reno, David Stracuzzi, and Craig Vineyard join the seven other Sandia experts who specialize in a variety of areas including optical engineering, remote sensing, chemistry, solar energy, and fluid dynamics.

Sandia's participation and expanding presence in the LPS is just one of the many ways it meets its government-mandated technology transfer mission and moves federally funded research to market, creating economic development.



Sandia Researcher Raga Krishnakumar working with mammalian cells in a biosafety cabinet for a project exploring cell therapy for infectious disease.

To learn more about the Lab Partnering Service, visit <https://www.labpartnering.org/>



Innovation and Intellectual Property Celebrations



Sandia National Laboratories' Integrated Partnerships Organizations hosted Innovation and Intellectual Property (IP) Celebrations in both New Mexico and California. The annual events honor the innovative culture and intellectual property generated by Sandia's scientists, engineers, and technologists.

In New Mexico, awards were given to 198 patent inventors and 42 copyright authors for copyrights asserted in calendar year 2018. The event also recognized 43 Mission Innovators, who were nominated by their divisions for innovation in support of Sandia's national security missions. California recognized 31 patent inventors, 7 Classified Intellectual Property Awards inventors, and 17 royalty generators.

Awards were also presented in New Mexico to 15 director-nominated Up & Coming Innovators, honoring early career Sandians who exhibit entrepreneurial talent, develop unique solutions to complex scientific challenges, and display potential to make significant contributions to the Labs' IP portfolio.

Former Sandian Greg Sommer was recognized as the 3rd Entrepreneurial Hall of Fame inductee at the California celebration. Sommer co-founded [Sandstone Diagnostics](#) to commercialize medical devices based on Sandia's SpinDx™ technology, which Sommer helped invent. Sandstone launched the Trak Male Fertility Testing System—an FDA-cleared, over-the-counter device that allows men to measure and track sperm count at home to help couples improve their chances of conception.

NMSBA Innovation Celebrations



Projects that achieved outstanding innovations through the New Mexico Small Business Assistance (NMSBA) Program in 2018 were honored at three Innovation Celebrations in 2019 in Santa Fe, Albuquerque, and Gallup.

Five of these projects received technical assistance from Sandia. [Advanced Optical Technologies](#) has obtained funding based on results of studies comparing their non-destructive titanium test method with the current industry standard. The [Meow Wolf](#) Leveraged Project added a new 11-person Digital Storytelling Team after assistance with sensor systems and other mixed-reality technologies. [Monarch Waste Technologies](#) received an EPA exemption allowing for expansion of the company after chemical analyses of their pyrolysis approach. The [Rope Rescue](#) Leveraged Project is making rope rescues safer after receiving drop tower test results.

One project received the *Honorable Speaker Ben Luján Award for Small Business Excellence* for demonstrating the most economic impact. Rhino Health has already hired about 35 people and is producing nitrile gloves at their facility in Gallup where they anticipate investing more than \$45 million and creating up to 350 jobs.

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.

Artificial Diversity and Defense Security (ADDSec)

Automatically detects and responds to threats within critical infrastructure environments in real-time. An ensemble of machine learning algorithms classifies threats and activates moving target defense strategies.

Cloud Hypervisor-forensics and Incident Response Platform (CHIRP)



Forensic and incident response tools have not evolved to combat advancing threats to Cloud security. CHIRP is an innovative Virtual Machine (VM) Introspection tool that transparently interacts with VMs to extract data to aid with forensics and incident response in a real-time fashion.

High-Performance Nanoantenna-Enabled Detectors (NEDs)



Nanoantenna-enabled-detectors use a new architecture that leads to more signal from a longwave infrared (thermal) source while having a lower dark current. This provides better quality images while using standard materials and fabrication processes.

Multiscale Inverse Rapid Group-Theory for Engineered Metamaterials (MIRaGE)



The first software tool using group theory for the inverse design of optical metamaterials; it supports design, simulation, and optimization. Effective optical properties are related to the spatial symmetries of metamaterial unit cells, allowing for specification of the desired electromagnetic behavior.

R&D 100 Special Recognition Medalists

Green Tech

GOLD: SiC-Based Monolithic Transistor-Rectifier Semiconductor Switch

The industry's first commercially available silicon-carbide, transistor rectifier on a single chip. (Collaborator: GeneSiC Semiconductor, Inc.)

SILVER: Ducted Fuel Injection

A simple, mechanical device that can reduce the most-problematic pollutant emissions from highly efficient heavy-duty diesel engines by 50% to 100%.

Market Disruptor – Products

BRONZE: Stable Nanocrystalline Metal Alloy Coatings with Ultra-Low Wear



A platinum-based alloy that is extremely wear-resistant, using a technique called grain boundary segregation to create highly stable nanocrystallinity.

FLC Awards

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

FLC Mid-Continent & Far West Region Awards

Excellence in Technology Transfer

Small Reactor to Help Solve Worldwide Medical Isotope Shortage

Sandia's concept to produce medical isotopes with a small, 2-megawatt reactor using low-enriched uranium was licensed by Eden Radioisotopes, LLC in order to produce a more reliable domestic supply of the in-demand isotopes.

Notable Technology Development

Detergent-Assisted Fabrication of Multifunctional Nanomaterials



Uniform multifunctional particles outperform commercial varieties and could be used in many applications including environmental clean-up and cancer treatment.

Stable Nanocrystalline Metal Alloy Coatings with Ultra-Low Wear



The world's most wear-resistant alloy that is 100 times more durable than high-strength steel, and could make electronics more cost-effective, long-lasting, and dependable.

Outstanding Partnership

Zero-V Hydrogen Fuel Cell Research Vessel

Research showed it is technically and economically feasible to build a zero-emissions research vessel that meets marine regulations and doesn't pollute the air or ocean.

Other Awards

DOE Technology Transfer Working Group Awards

Best in Class for Licensing

Bob Westervelt and Kevin Bieg were recognized for their work on the Eden Radioisotopes license.

Member of the Year

Jason Martinez was recognized for his numerous contributions over the years, most recently as the chair of the FY19 TTWG Agreements Subcommittee.

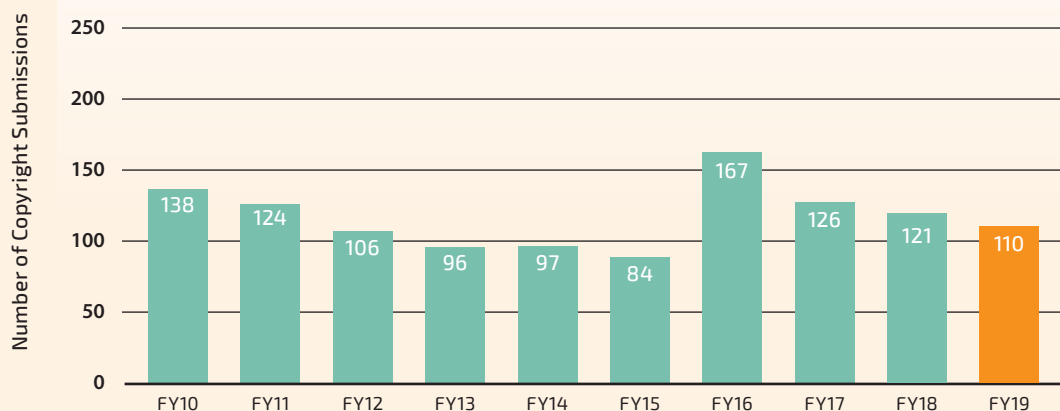
New Mexico Technology Council

Women in Technology Awards

Amy Halloran was recognized for her professional achievements, mentoring and advancing other women in STEM careers, contributions to the technology community, and leadership skills.

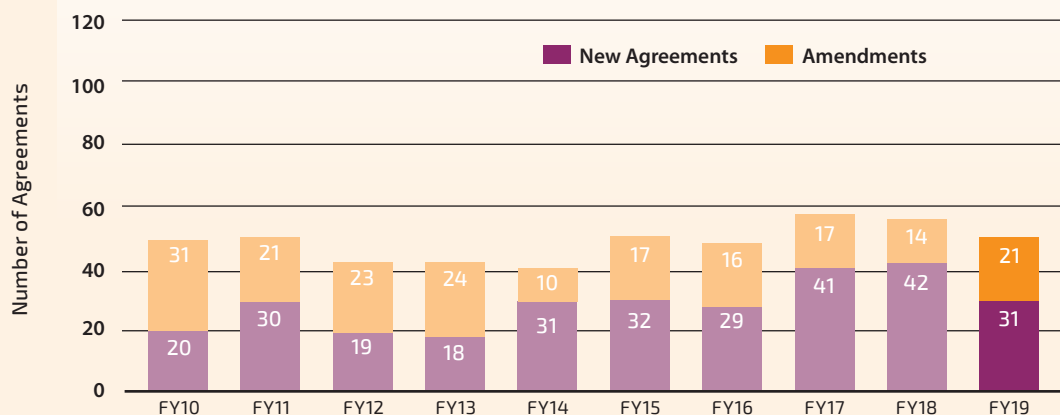
Copyrights

Copyright Submissions

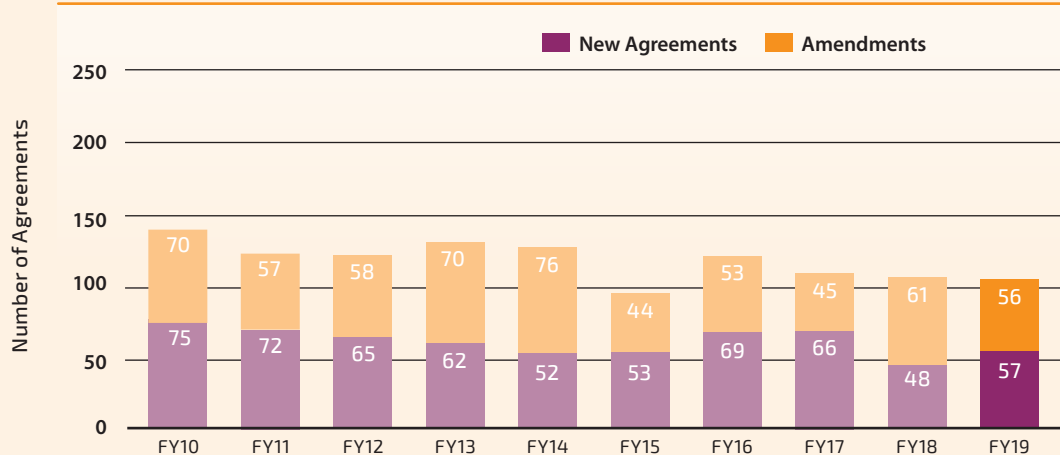


CRADAs and SPP/NFE Agreements

Cooperative Research and Development Agreements (CRADAs)

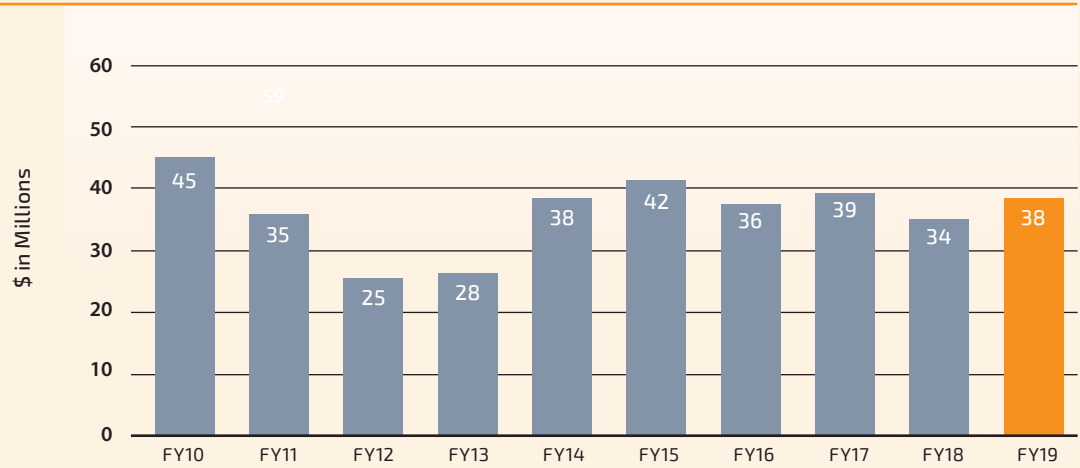


Strategic Partnership Projects/Non-Federal Entity (SPPs/NFE) Agreements



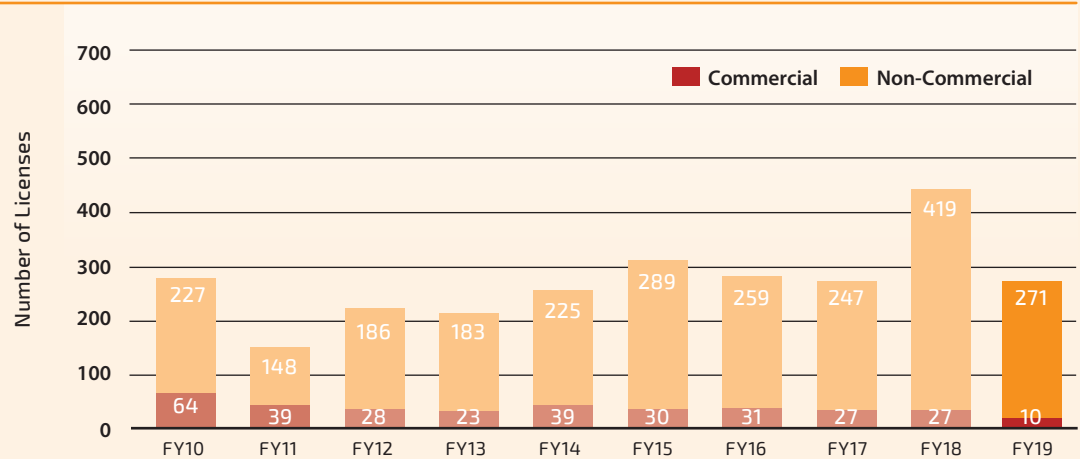
Industry Funds-In

Industry Funds-In to Sandia (\$M)

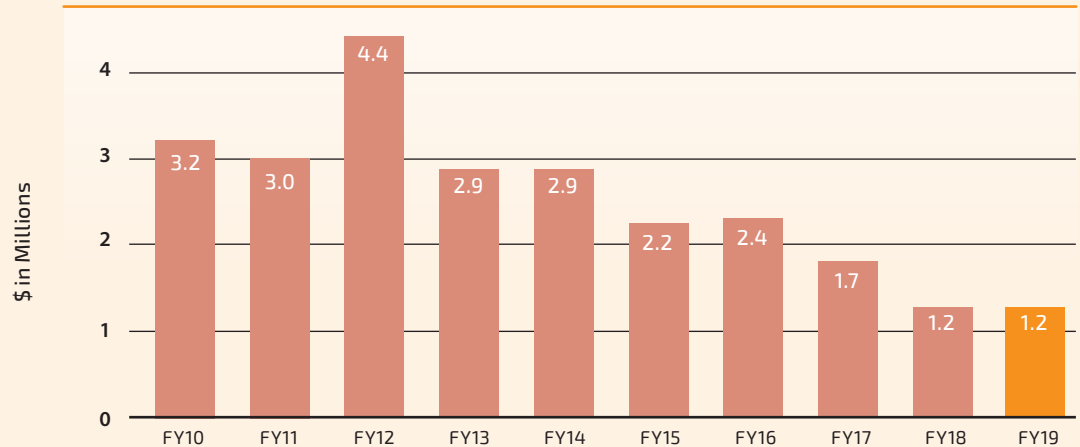


Licenses

Licenses

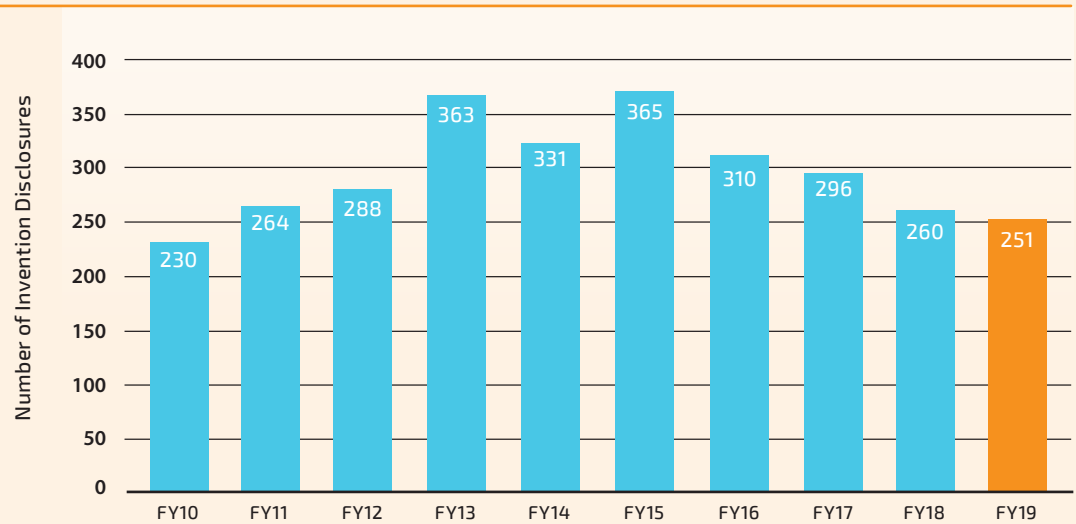


Licensing Income (\$M)

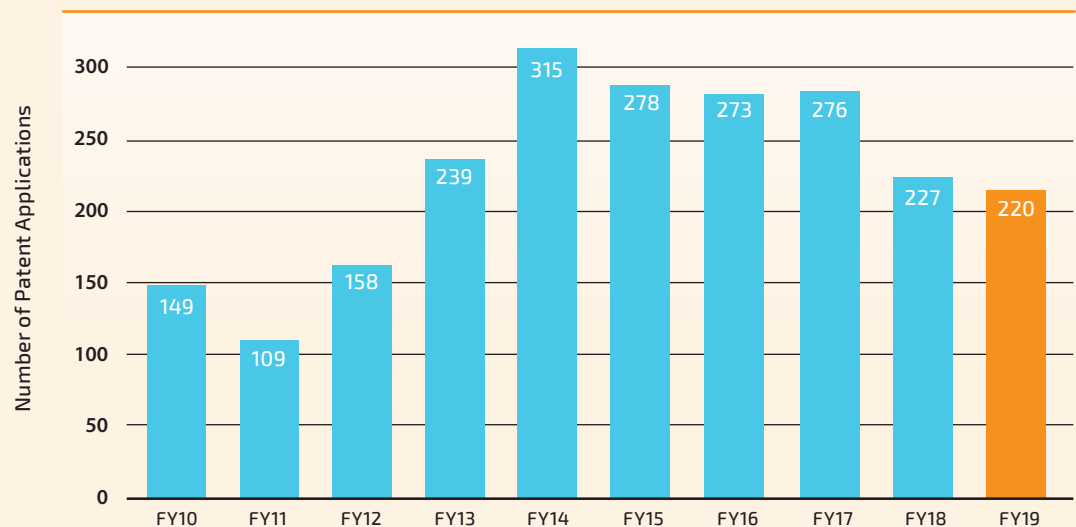


Patent Activity

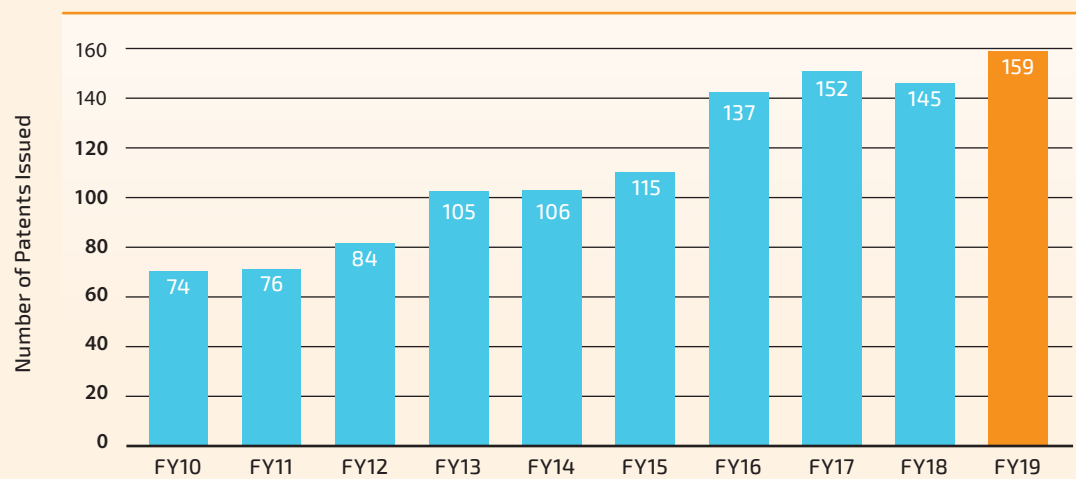
Invention Disclosures



Patent Applications



Patents Issued



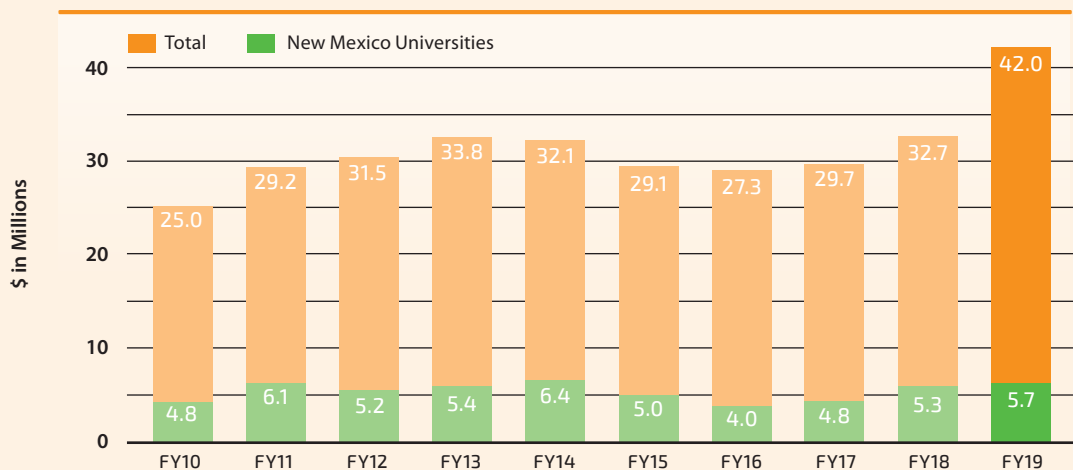
University Partnerships

Since 1997, Sandia National Laboratories has formally contracted for university research to expand its science and technology base. Both Sandia and universities share a need to accelerate the creation of world-class research, develop scientists and engineers, and grow new competencies.

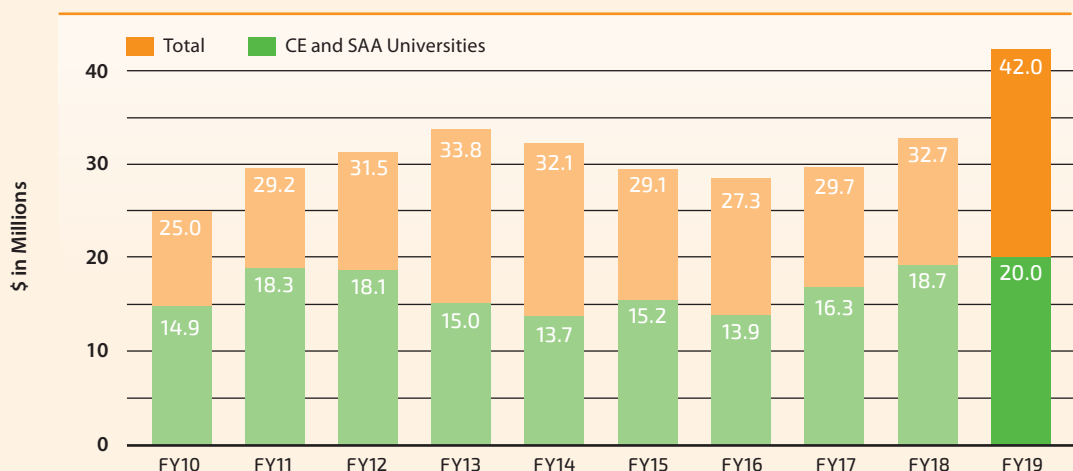
Sandia's university strategy encourages partnerships with various California, New Mexico, and national institutions. Through our Campus Executive program, we have formalized agreements with about 20 schools that define partnership goals, including research collaboration areas and talent pipeline objectives. In 2016, Sandia began more focused collaborations with a subset of the Campus Executive schools under its Sandia Academic Alliance (SAA) Program. These schools have had strong historical partnerships with Sandia, possess synergistic research competencies and capabilities, and share Sandia values and an affinity for national security work. They are working with Sandia to solve big problems, sustain and engage human capital, and accelerate adoption of new technology.

[The University Partnerships Office](#), under the auspices of the Chief Research Officer, serves as the point of contact for university research issues and implements those processes that enable university partnerships. In 2018, a New Mexico partnerships manager was added along with several staff members to facilitate university partnerships.

Investments in Research at New Mexico Universities



Investments in Research at Campus Executive (CE) and Sandia Academic Alliance (SAA) Universities



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

Sandia Science & Technology Park (SS&TP)

Companies and Organizations	48
Employees	2369
Buildings	26
Public Investment in the Park*	\$90M
Private Investment in the Park*	\$306M
Total Investment in the Park*	\$396M
Increase in Tax Revenue*	\$3.1B
Increase in Wages*	\$5.4B
Average Salary of Full-time Jobs in Park	\$98K
Average Salary of Full-time Jobs in Metro Albuquerque	\$46K

*Since Park opened in 1998.

2019

During the calendar year, five companies moved into the Park: Dynetics Technical Solutions, Excelligent, Peerless Technologies, TechSource, and X-Bow Systems and three companies committed to moving into the Park: Cooperative Educational Services, IDEAS Engineering & Technology, and PNM.



New Mexico Small Business Assistance (NMSBA)

Sandia: 2000-2019	
New Mexico Small Businesses Assisted	2344
Rural vs Urban Businesses	
Rural (60%)	1397
Urban (40%)	947
Combined	2344
Dollar Amount of Assistance	\$41.2M

Sandia and Los Alamos: 2000-2018*

Return on Investment (ROI)**	\$1.49
(For every \$1.00 of state tax credit invested)	
Economic Impact	
Small Business Jobs Created and Retained	8778
Average Reported Salary (2018)	\$50K
Increase in Revenue	\$396M
Decrease in Operating Costs	\$203M
Investment in NM Goods/Services	\$140M
New Funding/Financing Received	\$176M

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

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

2019

Sandia invested \$2.4M helping 192 small businesses in 21 counties throughout New Mexico during the calendar year. There were 75 Sandia principal investigators across 57 departments that supported NMSBA.



Entrepreneurial Separation to Transfer Technology (ESTT)*

Sandians Who Left on ESTT	162
To Start up a Company	74
To Expand a Company	88
Companies Affected by ESTT	113
Start-up Companies	58
Expansion Companies	55

*Since ESTT began in 1994.

2019

Four Sandia entrepreneurs are currently out on ESTT.



Center for Collaboration and Commercialization (C3)/ Entrepreneur Exploration (EEx)*

Entrepreneur Events	88
Participants	4064

*Since EEx began in 2015.

2019

During the fiscal year, EEx held 20 entrepreneur events with a total of 745 participants.



Entrepreneur Exploration

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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.

www.sandia.gov/partnerships_reach



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

