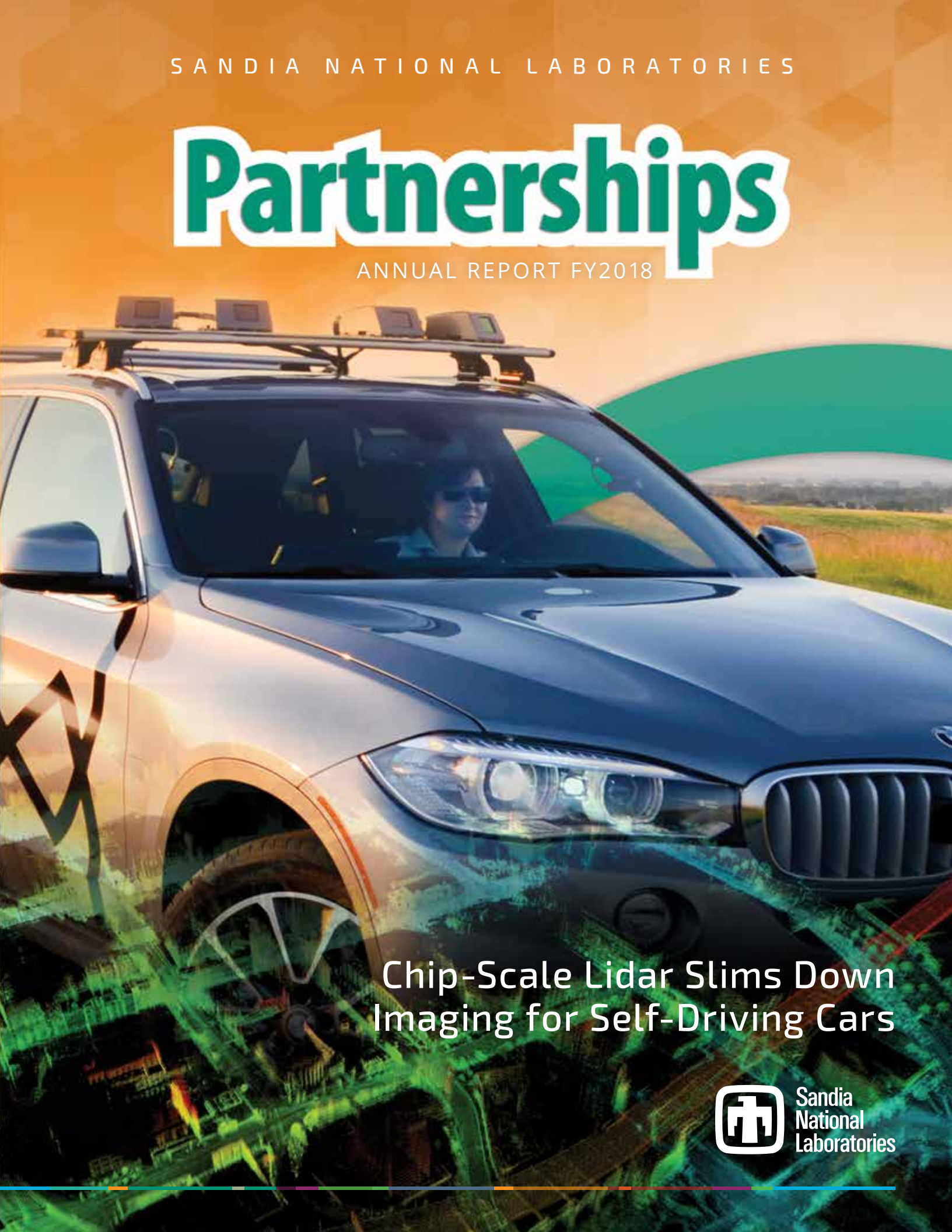
SANDIA NATIONAL LABORATORIES

Partnerships

ANNUAL REPORT FY2018



Chip-Scale Lidar Slims Down Imaging for Self-Driving Cars

Sandia National Laboratories

"The commercialization and adoption of innovative technologies is a critical aspect of how the Department of Energy and its national laboratories fulfill their mission to advance the economic and national security interests of the nation. We salute Sandia's outstanding work in technology transfer, including its service as the chair of the Technology Transfer Working Group, and we look forward to another year of excellence and achievement."

— *Conner Prochaska*
Director Office of Technology Transitions
U.S. Department of Energy (DOE)

"Sandia's spirit of innovation and discovery remains strong, resulting in an expanding portfolio of remarkable inventions and world-class technologies. Our technology partnerships enable us to enhance our nation's security and economic competitiveness through the successful technologies transferred into the industrial marketplace."

— Dan Sanchez
DOE Technology Partnerships Manager
NNSA Sandia Field Office

"As a Federally Funded Research and Development Center, Sandia develops creative solutions to complex challenges. Our Partnerships Program helps bring many of these technologies to the marketplace so that millions of Americans can benefit from Sandia's innovations. Technology transfer strengthens Sandia and increases U.S. economic prosperity and competitiveness."

— Steve Younger
Laboratories Director
Sandia National Laboratories

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About the cover:
A Doppler lidar map of downtown San Francisco shows some of the Bay Area's busy highways and congested streets where Blackmore Sensors and Analytics has conducted vehicle testing.

See story on page 18.

INTRODUCTION

"Partnerships enhance our ability to fulfill our national security mission. Collaborating with industry, academia, and other national laboratories helps us leverage our capabilities, resulting in new technologies that are applied to securing our nation and safeguarding the public."

— **Susan Seestrom**

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

"Working with universities benefits both Sandia and its partners. Ideas and capabilities are shared, and together, larger problems can be solved. Interactions with academic institutions give students a window into the exciting research opportunities available at Sandia and give Sandia access to new talent."

— **Grant Heffelfinger**

Director
Research & Development Science and Engineering
Sandia National Laboratories

"As part of its technology transfer mission, Sandia is an active participant in DOE programs designed to strengthen America's competitiveness. To further accelerate technology transfer, Sandia has pioneered its own programs to facilitate interaction with industrial, academic, and government partners. These efforts have made Sandia a leader in commercialization of lab-developed technologies."

— **Mary Monson**

Senior Manager
Technology Partnerships & Business Development
Sandia National Laboratories

Partnering for Mission Success

Sandia National Laboratories uses strategic partnerships to enhance its ability to deliver on its missions and meet national challenges. Partnerships with industry, other national laboratories, and universities strengthen Sandia capabilities and move technology towards adoption for the public good.

In some cases, technologies are being developed to directly address national security challenges. In others, technologies originally created for security or defense purposes are being adapted to create and enhance infrastructure and publicly available products.

This annual report highlights only a fraction of the hundreds of partnerships Sandia takes part in each year. Partnerships with industry, academia, and other government agencies are:

- Adapting technology originally developed for defense missions to make open rotor engine designs safer for commercial airplane passengers
- Using microgrid and cybersecurity expertise to develop DC microgrids to enhance the safety and resilience of the nation's energy system
- Realizing a more secure energy future by evaluating the feasibility of converting existing nuclear plants to hybrid plants that will produce hydrogen as well as electricity
- Understanding the changing Arctic environment and addressing energy challenges to help protect U.S. security
- Improving lidar for commercial autonomous vehicles using single chip beam-steering originally designed for mission-critical remote sensing applications

Besides helping Sandia deliver on its missions, partnerships are helping Sandia to improve its capabilities, develop new talent, leverage its strengths, facilitate technology transfer, and promote the nation's economic health through commercial competitiveness.

LDRD
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/ldrd

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.

BOEING

"Boeing's collaborative research with Sandia in the area of computational materials is enabling innovative, light-weight aircraft designs."

— Olaf Weckner

Structural Analysis Engineer
Boeing

Making New Open Rotor Engines Safer for Commercial Airplanes

CHALLENGE

In currently used commercial aircraft, engines are encased in a cowl. But new "open rotor" engine designs have fan blades in front of the engine casing, like a propeller engine. These new engines promise to lower fuel consumption.

However, an open rotor design means that the plane's fuselage needs to have a protective layer of armor that would prevent an engine fan blade from entering the passenger cabin in case a blade breaks off its rotor. This can sometimes occur due to a bird strike or material defect. The armor materials must be light to keep the airplane weight down for fuel efficiency, yet be strong enough to provide protection.

COLLABORATION

Sandia National Laboratories and Boeing worked together on this challenge through a project funded by NASA. Although most people are unaware of it, NASA does research into aircraft as well as space vehicles, and has contributed technology for decades that improves commercial aircraft efficiency and maintains safety.

A variety of composite materials are being considered for the plane's protective layer, but which would be safest, how thick would it need to be, and how will it interact with the airplane's other design features? Computational analysis will be used to predict how different composites would work in physical experiments.

SOLUTION

Sandia has been able to use peridynamics, a method of high performance computing analysis tool invented at the Labs' Center for Computing Research to help answer these questions. This analysis tool has been validated through its use on a variety of technical issues Sandia and Boeing have collaborated on over the years.

The partners found that peridynamics was more accurate than other methods in V50 predictions, or determining the velocity at which there was a 50% chance of a projectile like a broken engine fan blade penetrating the fuselage. Physical testing done during the initial phase of NASA's High Energy Dynamic Impact (HEDI) project confirmed the computational results and showed that Sandia's predictions were accurate in predicting the threshold velocity within about 11% of the measured value.

IMPACT

Originally funded by the DoD to look at problems involving impact, penetration, and fragmentation in military aircraft, peridynamics is now being used to solve problems for commercial aircraft design and create safer passenger planes. It is a good example of Sandia technology being adapted for multiple applications for the public good.

Boeing Engineers Fernando Cuenca and Olaf Weckner stand in front of a test panel that has been struck by a projectile, like the one Olaf is holding, launched by a gas gun at the NASA Glenn Research Center Ballistic Impact Lab.

PARTNERSHIP TYPE: *Umbrella Cooperative Research and Development Agreement (CRADA) and Strategic Partnership Project (SPP)*
GOAL: *Determining how to make new open rotor engine designs safer for commercial airplane passengers*

DECON7 SYSTEMS AND PLEASANTON RIDGE RESEARCH

Improving Blast Mitigation Foam to Better Protect the Public

"The UFC foam formula significantly reduces the product's weight, which makes logistics easier and reduces the expense of shipping. These factors should significantly expand the customer base for explosion attenuating foams and result in a positive impact on public safety."

— Mark Phillips
Managing Director
Pleasanton Ridge Research, LLC

and

— Matt Bluhm
CEO
Decon7 Systems, LLC

CHALLENGE

Aqueous Foam Concentrate (AFC) 380 is a foam which envelops an explosive device to dramatically decrease blast effects and mitigate dispersed particles if a device is activated. It has been used by first responders and bomb squads in military and law enforcement when they have to deal with explosive hazards which can be laced with chemical, biological, or radiological materials.

COLLABORATION

When the single original manufacturer was no longer able to provide a consistent supply, Sandia National Laboratories signed up two new companies to overcome this challenge. It was important to find manufacturers willing to take on this much needed product in the relatively small, yet essential emergency response market. Having two suppliers provides redundancy and an assured supply of explosion attenuating foam.

Decon7 Systems and Pleasanton Ridge Research were found after a search for companies to be the new licensees. These companies are now not only manufacturing and selling the AFC 380, they are also working with Sandia to develop the next generation of the foam formula, the Ultra Foam Concentrate (UFC). UFC has an increased shelf life, weighs significantly less so it's easier to transport, and has enhanced shelf stability.

SOLUTION

By working with the two companies, there will be a consistent supply of blast mitigation foam. The next generation of the foam researched by Sandia can also be developed into a manufacturable product. The new UFC will let first responders have a product with improved performance that is more environmentally friendly. It is more concentrated so it is a lighter load to carry in the field and its shelf life has been enhanced so it can be stored for longer periods of time without losing effectiveness.

IMPACT

AFC-380 is used by members of the U.S. emergency response community to reduce blast dispersions, such as those occurring from acts of terrorism. Developing UFC will give them an improved product and more assured supply which means this Sandia-developed product will be available to those who need it, when they need it. Continual improvements also mean that first responders will always have the best possible way to protect themselves and the public from the effects of bomb blasts.

Emergency responders train with the Sandia-developed blast mitigation foam.

PARTNERSHIP TYPE: *Licenses*
GOAL: *Assuring a steady supply and continual improvement of blast mitigation foam for first responders*

EMERA TECHNOLOGIES

Enhancing the Efficiency and Security of the Nation's Power Grid

"Industry partnerships with Sandia result in technology commercialization, economic growth, and jobs. Relationships like this keep America on the forefront of technological achievement."

— Gary Oppedahl

Vice-President of Emerging Technologies
Emera Technologies

CHALLENGE

How will the power grid be sustainable in the future? New sources of power, such as solar and wind, are coming on-line. Hurricanes and other major disasters disrupt power, sometimes for months.

At the same time, there is a need to protect privacy and security. New power grids are bidirectional—energy is being added to the grid as well as being taken out. How do you keep the exchange of energy-related data between the utility and customers secure?

COLLABORATION

Emera Technologies, a part of Emera Inc., an energy and utility company with affiliates in the Caribbean, Florida, and New Mexico, is working with Sandia National Laboratories to create scalable, renewable-rich direct current (DC) microgrids as a way to enhance the safety, security, efficiency, and resilience of the nation's energy system.

Sandia has unique capabilities and experience in both microgrids and cybersecurity, so is well suited to partner with Emera Technologies on these issues. Most of Sandia's prior microgrid work has been with alternating current (AC) microgrids. But this partnership will study the fundamental gaps in knowledge associated with expanding the scale of DC microgrids.

AC microgrids are commonly used in remote and island communities and some military bases and industrial applications, but a large and growing portion of electricity used in homes is DC, forcing an inefficient conversion from AC to DC to make everything work.

SOLUTION

Emera Technologies is interested in applying DC microgrids to community scale applications. DC systems are not new—they are found inside your cell phone, laptop, and cars, but what is different is the larger scale. The utility company is interested in this concept because it has the promise to provide higher reliability, facilitate integration of renewable resources like solar, and to become a viable alternative to supply electricity to new industrial areas or housing subdivisions.

New power electronics hardware, controls, and protection systems will be required to build a DC microgrid, and Sandia can help determine what is needed and give suppliers ideas and designs that can be manufactured.

IMPACT

An in-context research application is planned for Kirtland Air Force Base and next a community-scale commercial demonstration. The technology developed for DC microgrids can also be applied broadly to other critical infrastructure. Work done through this partnership could lead to the energy generation and distribution system of the future, one that is renewable and sustainable, providing energy security for the U.S.

Sandia Manager Abraham Ellis and Technologist Roy Lopez discuss future plans using the Labs' Secure Scalable Microgrid Testbed.

PARTNERSHIP TYPE: *Umbrella Cooperative Research and Development Agreement (CRADA)*
GOAL: *Creating scalable, renewable-rich DC microgrids as a way to enhance the safety, efficiency, and security of the nation's energy system*

R3 TECHNOLOGIES

Saving Lives by Detecting Threats with Polarized Radar Technology

"Without Sandia's help through the NMSBA program and a CRADA, we would have never gotten to where we are today, getting close to a having a deliverable product."

— **Robby Roberson**
President
R3 Technologies

CHALLENGE

It has been difficult to protect the civilian population from suicide bombers who might be carrying bombs under their clothing. R3 Technologies (R3T) had a Concealed Bomb Detector, the CBD-1000, but needed to improve its consistency and accuracy.

This system uses polarized radar returns to detect bombs missed by current metal detector technology. The CBD-1000 is intended for screening areas such as airports, embassies, public and government buildings, border crossings, transportation hubs, and military compounds.

Like polarized sunglasses being used to help you see things you can't see well with regular glasses, polarized radar also improves on regular radar, making it good for IED or intruder detection.

COLLABORATION

Through the New Mexico Small Business Assistance (NMSBA) Program, R3T President Robby Roberson was connected with JR Russell and his team at Sandia National Laboratories. They were able to study all the existing detector hardware and software and work to improve the accuracy of the scans. R3T has now reconfigured the hardware based on Sandia's recommendations and rewritten the software to do a better job of signal processing and image analysis.

SOLUTION

The increased signal to noise ratio is allowing the CBD-1000 to see things that weren't obvious before. It is now able to perform scans dynamically, as people walk by the detector rather than as they are stopped in front of it. The R3T–Sandia team has also demonstrated the ability to increase the range of detection from 9 to 100 feet to meet customer requirements. A CRADA has been signed to further the work.

This capability could also be used for DOE, DoD, and DHS security perimeters where mono-static and bi-static microwave systems are commonly used. An LDRD project is exploring if the polarized radar technology can differentiate manmade from non-manmade targets from an unmanned aerial vehicle (UAV).

IMPACT

R3T now has a global technology, defense, and engineering group as a marketing partner. R3T and Sandia are also working with Pi8 Solutions, a woman-owned New Mexico business, to embed the CBD-1000 in Pi8's detection/protection Portal and Vestibule Concealed Weapons Detection Systems.

Researching this technology has also strengthened Sandia scientists' understanding of polarized radar and the associated signal processing, adding a new capability. "We want to help our nation protect our people, our assets," Russell said. "If we can save one life, we can make a difference."

Wearing a mock suicide vest, Robby Roberson stands in front of his company's CBD-1000 bomb detector, being adjusted by Sandia Scientist JR Russell.

PARTNERSHIP TYPE: *Cooperative Research and Development Agreement (CRADA) and New Mexico Small Business Assistance (NMSBA)*
GOAL: *Improving a concealed bomb detector and finding new applications for its polarized radar technology*

IDAHO NATIONAL LABORATORY

Evaluating Hybrid Nuclear Plants for a Secure Energy Future

"This CRADA plays a key role in securing a future role for the nation's existing fleet of nuclear reactors, and advanced reactors of the future. The unique capabilities of the participating Labs—especially the support of Sandia relative to safety codes and standards—are critical to the success of this project."

— Richard Boardman
Manager
Idaho National Laboratory

CHALLENGE

To enhance the flexibility and viability of nuclear power, the DOE Hydrogen at Scale (H2@Scale) initiative is studying "hybrid energy systems" that can monetize nuclear generation in a variety of applications. One idea is to use the heat and electricity produced by existing nuclear power plants to produce bulk hydrogen during times when electricity generation is less profitable. This would also help diversify hydrogen production and provide hydrogen for a growing number of industrial applications.

COLLABORATION

Led by the DOE's Office of Energy Efficiency and Renewable Energy's Fuel Cell Technologies Office, in collaboration with multiple other DOE offices, the H2@Scale concept brings together stakeholders to advance affordable hydrogen production, transport, storage, and utilization to increase revenue opportunities in multiple energy sectors. An industry-led multi-lab H2@Scale project has collaborators from Idaho National Laboratory (INL), the National Renewable Energy Laboratory (NREL), Argonne National Laboratory (ANL), and Sandia National Laboratories studying the technical feasibility and business case for using a nuclear power plant to produce hydrogen for energy storage, industrial uses, and fuel cell vehicle filling stations.

INL is the lead lab bringing expertise in systems modeling software to identify optimal configurations for nuclear hydrogen hybrid systems. NREL is contributing modeling and simulation tools pertaining to the electrical grid, energy pricing, and economic analysis. ANL brings expertise with fuel cell vehicle and hydrogen infrastructure costs. Nuclear energy and fuel cell researchers at Sandia are contributing their expertise regarding hydrogen safety and permitting requirements that should be met to site a hydrogen production facility next to a nuclear reactor.

SOLUTION

This evaluation will assess the viability of hydrogen production using heat and electricity from nuclear power plants during times of the year when conventional electricity production is less profitable. The approach could increase the capacity factor of nuclear power plants, and generate low-cost hydrogen supply for a diversity of emerging end users.

IMPACT

Hydrogen and fuel cell technologies are critical for realizing a secure energy future and helping to diversify America's energy sector. Hybrid energy systems, such as those being explored in the partnership, can enable low-cost hydrogen supply for rapidly growing fuel cell industries including transportation while also supporting nuclear baseload power. While this project is being explored at a single Exelon Generation nuclear plant, its conclusions will be relevant to the nuclear and hydrogen industry as a whole. FuelCell Energy, Inc. is also participating in this CRADA.

This project will culminate in an investor-grade assessment report that is hoped will advance commercial projects.

Idaho National Laboratory Researcher Jong Suk Kim evaluates optimal nuclear-integrated hydrogen production system designs.

PARTNERSHIP TYPE: *Cooperative Research and Development Agreement (CRADA)*
GOAL: *Evaluating the value proposition of converting existing nuclear reactors to hybrid plants that produce hydrogen*

PURDUE UNIVERSITY

Sandia and Purdue signed an Academic Alliance Partnership MOU in 2015 to conduct joint research in a number of technical areas aligned with the strengths and missions of both institutions. Current collaborations focus on hypersonics and propulsion systems research, quantum computing, cybersecurity, data science, and complex systems.

Studying Structural Improvements for Hypersonic Vehicle Design

"The collaboration between Purdue and Sandia on hypersonics facilitates bridging the gap between university science research and Sandia engineering for DoD applications."

— Steven Schneider

Professor
Aerospace Sciences Lab
Purdue University

CHALLENGE

Hypersonic vehicles, which travel at speeds faster than five times the speed of sound, experience significant thermal and aerodynamic loads. They could be used for multiple potential missions including manned and unmanned civil reentry, planetary entry probes, and defense.

Hypersonic reentry vehicles are subjected to high levels of fluctuating pressures. These intense fluctuations can cause vibration of internal components and lead to structural problems. To design better hypersonic flight vehicles, there is a need to predict pressure fluctuations.

COLLABORATION

Computers can model how the boundary layer turbulence will be transmitted through the structure and shake internal components, but the models must be compared to measurements from physical testing in a wind tunnel. Purdue University and Sandia National Laboratories are working together on this challenge.

While Sandia has conventional wind tunnels, Purdue developed and operates a "quiet" hypersonic wind tunnel, one of only four in the world. The quiet tunnel is critical for recreating the smooth, or laminar, flow of air over the surfaces of aircraft, spacecraft or missiles within the Earth's atmosphere. It also helps determine when the flow over the flight vehicle might become turbulent: the point where much higher pressure fluctuations are generated.

SOLUTION

Studying these pressure fluctuations has a big effect on how the structure of hypersonic vehicles is engineered. While vehicles must be designed for survivability, having better predictions and data can help engineers create vehicles that are not overdesigned. Wind tunnel testing also lets researchers refine the physics in their computer models, making them more accurate.

Testing results are already contributing to a better understanding of turbulence and how it creates pressure fluctuations in hypersonic vehicles. Having access to the quiet wind tunnel gives Sandia researchers an opportunity to validate and improve their models at Mach 6. A large new Mach 8 quiet tunnel to be built at Purdue should enable even better simulations.

IMPACT

Purdue's research leads the world in laminar-turbulent transition in hypersonic flows and Professor Steven Schneider is an expert in developing mechanism-based methods for estimating hypersonic boundary-layer transition in flight. Due to this partnership, the expertise available at Purdue is shared with Sandia. In addition, a number of Purdue aerospace students have become interns and employees at Sandia, advancing the Labs' research and engineering capabilities in the area of hypersonics.

Purdue Graduate Student and Sandia Intern Kathryn Gray inspects a model being tested in the Purdue quiet wind tunnel.

PARTNERSHIP TYPE: *Collaborative Research and Academic Alliance*
GOAL: *Improving hypersonic vehicle design and extending research capabilities*

Understanding Challenges of a Changing Arctic for U.S. Energy and Security

"The relationship between UAF and Sandia researchers has never been stronger. We are excited as we look forward to many years of productive and innovative collaboration."

— Nettie LaBelle-Hamer

Deputy Director
Geophysical Institute
University of Alaska Fairbanks

CHALLENGE

The Arctic is undergoing rapid change, with sea ice melting and temperatures rising at a faster pace than anywhere else in the world. Its changing environment affects global security, politics, the economy, and the climate.

Understanding these changes is crucial for shaping and safeguarding U.S. security. Sandia National Laboratories and the University of Alaska Fairbanks (UAF) signed an umbrella CRADA to study these challenges and partner on research in the Arctic.

The agreement includes working toward a comprehensive multiagency research facility, supporting Alaska's resilience against natural disasters and the harsh environment, studying the suitability of renewable energy and microgrids, flying tethered balloons and drones to measure atmospheric temperatures, and collaborating on satellite sensing, detection, and nonproliferation work.

COLLABORATION

Sandia and UAF have maintained a strong relationship for over a decade. Sandia operates facilities in the High Arctic for the DOE, and UAF has extensive research experience throughout the Arctic. The CRADA facilitates their joint research.

Sandia's experience includes twenty years of climate measurement on the Arctic coast, energy assessments for Alaska native villages, nuclear materials management for the Air Force, remote sensing of permafrost, computer modeling of the melting of the Greenland ice sheet, and the use of airborne synthetic aperture radar to detect subsurface changes in land and sea ice. UAF does extensive research on such Arctic issues as permafrost, coastal erosion, sea ice, search and rescue operations, glaciers, remote energy systems, and more.

SOLUTION

As part of the CRADA, the partners have proposed USHARC, the U.S. High Arctic Research Center at Oliktok Point, Alaska. The center would bring together stakeholders from science, safety, and security to develop comprehensive solutions for Arctic challenges. USHARC would include an unmanned aircraft systems (UAS) facility. The center would also offer logistical support; access to varied ecological settings; and it could support testing for technologies such as autonomous platforms, renewable energies, microgrids, and sensors. USHARC would utilize existing Sandia and UAF assets and capabilities to serve national needs.

IMPACT

USHARC will provide a multi-disciplinary, year-round High Arctic Center to conduct cooperative scientific research, identify appropriate Arctic technologies, and support field tests and exercises. This will enable advances in the development, resilience, preservation, and stewardship of Arctic resources, communities, and environment.

Inter-stakeholder collaborations and establishment of an Arctic station network will advance U.S. knowledge and monitoring of the Arctic to improve environmental stewardship, security, and sustained economic opportunity.

Sandia Researchers Dari Dexheimer and Casey Longbottom conduct offshore balloon tests in the Arctic.

PARTNERSHIP TYPE: *Umbrella Cooperative Research and Development Agreement (CRADA)*
GOAL: *Understanding the changing Arctic environment and addressing energy challenges to help protect U.S. security*

"Working with Sandia has provided Blackmore a window into the future of beamscanning technology for autonomous vehicle lidar. Sandia is helping us to realize practical technology solutions to present technology challenges."

— Stephen Crouch

CTO
Blackmore Sensors and Analytics, Inc.

Smaller Imaging System a Big Improvement for Self-Driving Cars

CHALLENGE

Autonomous vehicles, or cars that drive themselves, use a variety of imaging technologies such as optical cameras and radar to see other cars, people, and their surroundings. Traditional lidar—systems that measure distance with sensors and reflected light—rely on mechanical parts, such as gimbals, mirrors, and motors, to steer a laser beam across an area. These moving parts add weight and more potential failure points to the system. Ideally, lidar systems used on autonomous vehicles would be non-mechanical, with beam-steering accomplished using purely electronic controls. This would help lidar slim down from a bulky external box to multiple tiny chips seamlessly integrated into existing car components.

COLLABORATION

Blackmore Sensors and Analytics is partnering with Sandia National Laboratories to improve lidar for autonomous driving systems. The company is a pioneer in Doppler lidar sensors and supporting analytic tools and software. They are licensing Sandia's chip-scale optical array for beam-steering for use in their products.

Sandia's ability to design, simulate, fabricate, and package devices has simplified and sped up development of this major component of Blackmore's advanced lidar system. Blackmore's expertise in lidar systems combined with Sandia's experience in integrated silicon photonics technology is enabling the company to develop a more robust lidar system for use in commercial autonomous vehicles.

Blackmore Mechanical Engineer Allison Otten works with optical fibers in the company's production area.

Blackmore regularly tests automotive lidar units on the road while collaborating with Sandia researchers to validate optical phased array scanners in the lab.

SOLUTION

This integrated chip technology simplifies the manufacturing process, allowing large scale production at a significantly lower cost with reduced production times. Sandia is currently perfecting the fabrication and packaging process, which will be transferred to a commercial foundry for mass production when complete. Fabrication of prototype chips is being conducted at Sandia's Microsystems and Engineering Sciences Applications (MESA) Complex.

Unlike lidar systems that rely on mechanical parts to steer a laser beam, the Sandia-developed optical array incorporates beam-steering onto a single chip, allowing Blackmore to produce a complete lidar system with significantly reduced power requirements, increased longevity, and improved durability. The integrated chip technology leverages the decades of photonic innovations by researchers at Sandia's National Security Photonics Center (https://www.sandia.gov/mesa/nspc/).

IMPACT

Sandia's optical array for beam-steering was originally developed for the Defense Advanced Research Projects Agency's SWEEPER program, which aimed to develop a compact, agile alternative to mechanical beam-steering. This partnership has allowed Sandia to further refine optical phased array technology and can enable the use of remote sensing systems for a variety of mission applications. While Blackmore's focus for the technology is currently on lidar systems for autonomous driving, the company hopes to expand this groundbreaking technology to other industries.

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

GOAL: *Developing a chip-scale lidar system for use in commercial autonomous vehicles*

Supporting Weapon Systems Testing in Simulated Environments

Some members of the Test and Mk21 Fuze program teams, Sandians Richard Contreras, Tiffany Borges, Todd Barnett, Michael Judd, Anthony Tyson, and Elaine Yang, prepare to conduct a test of an Mk 21 unit.

The Environmental Test Facility (ETF) at Sandia National Laboratories, California, is a collection of labs capable of testing hardware to demonstrate performance and a system design's ability to withstand environmental factors including vibration, shock, temperature, altitude, and acceleration. The facilities are used to support weapon systems surveillance testing, and modernization programs such as the Mk21 Fuze Replacement Program.

The Mk21 fuze is an Arming and Fuzing Assembly (AFA) that arms the W87 warhead and triggers it at a prescribed point. The reentry vehicle is deployed on the U.S. Air Force Minuteman III Intercontinental Ballistic Missile (ICBM) and will be fielded on the new Ground Based Strategic Deterrent (GBSD) system.

This program leverages decades of experience in providing arming, fuzing, and firing systems for U.S. Navy ballistic missile warheads. Sandia is responsible for designing the components of the Mk21 replacement fuze that must survive hostile environments and normal environments. That's where the ETF fits in.

The ETF is designed to support integrated systems testing with the associated handling of hazardous materials. The facility contains test apparatus and equipment that provide environments that simulate conditions experienced by the weapon system in actual use. These are called Stockpile-to-Target Sequence (STS) environments.

The ETF staff partners with Sandia scientists and system engineers to design and perform tests that explore the boundaries of the warhead to STS environments. This is accomplished by using one-of-a-kind experimental equipment that closely mimics all STS environments. Unique equipment includes a dynamic test facility able to impart spin test inputs, a resonant plate facility that produces pyro shock like that experienced during separation, shock/vibration equipment used to assess response to design requirements, along with a space chamber capable of testing to a realistic altitude environment.

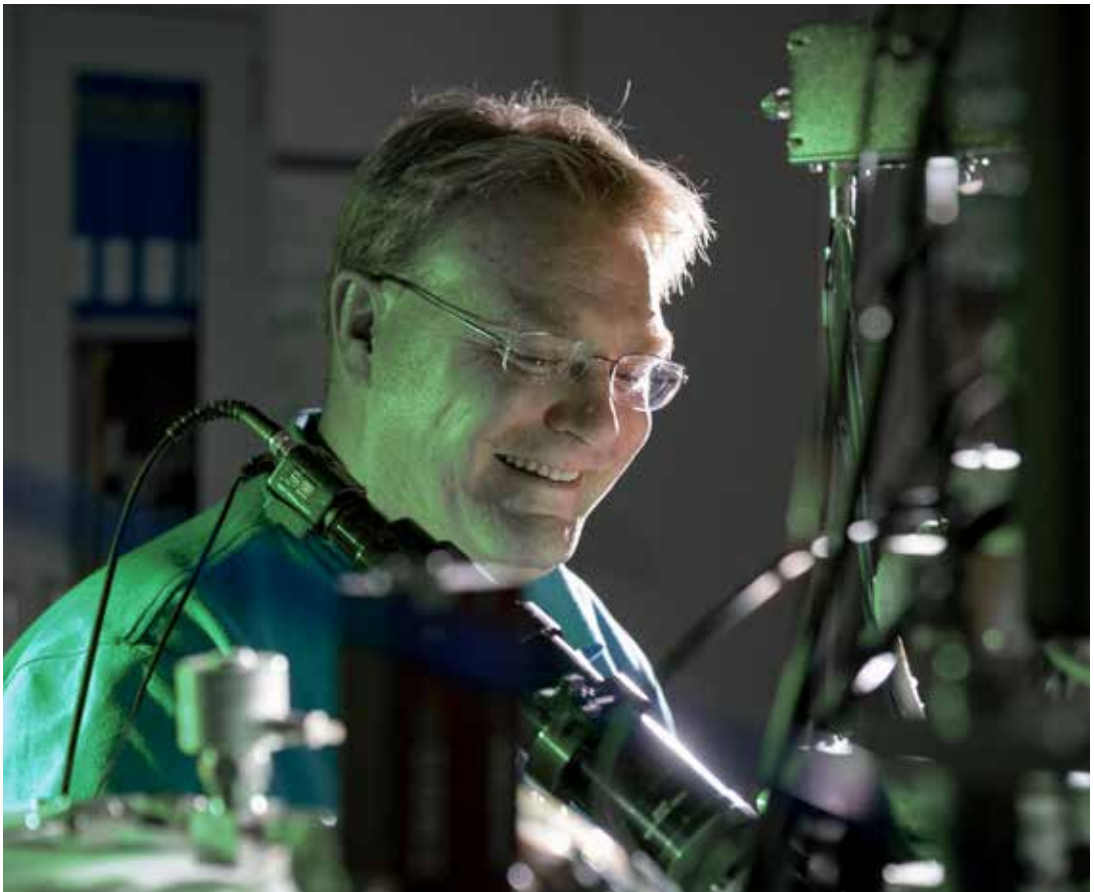
Fabricating Single Atom Devices for Quantum Information Science

The Ion Beam Laboratory (IBL) at Sandia National Laboratories provides state-of-the-art ion beam irradiation and implantation capabilities for a wide range of national security missions. The IBL explores radiation effects on semiconductor devices and materials, as well as on the structural and mechanical properties of metals. Focused ion beam implantation, allowing for the fabrication of single atom devices used for quantum information science (QIS), is also performed.

The IBL houses four main accelerators that can produce ions from elements ranging from hydrogen to gold with energies from electron volt to hundreds of megaelectron volt. One of these systems is the Nano-Implanter (NI). The NI is a 100 kilovoltage accelerator capable of running one-third of the periodic table of elements with a resolution of less than 10 nm. It allows for direct navigation from a computer-aided design (CAD) drawing and implantation of a single atom with nanometer scale resolution within prefabricated nanostructures.

In collaboration with multiple universities and national laboratories, Sandia's IBL has worked to fabricate single atom devices by implanting impurity atoms into high quality electronic grade diamond substrates. These impurity atoms form optically active defect centers which can be used for QIS, including single photon sources, quantum sensors, and quantum computation. Additionally, these defect centers can be used for metrology applications such as high resolution magnetic and electric field sensors and bio-compatible temperature sensors.

In integrated quantum nanophotonics research partnerships, diamond nanostructures are fabricated at multiple universities, implanted at the IBL, and then quantum optical measurements are performed at the universities' quantum optics laboratories. This is an example of each partner providing unique capabilities and expertise. The collaboration has resulted in multiple publications including two *Science* and two *Nature Communications* articles.



Sandia Scientist Ed Bielejec examines a material at the Ion Beam Laboratory with the Nano-Implanter, a machine that produces very precise material defects.

To learn more about the Ion Beam Laboratory, visit http://tours.sandia.gov/IBL/

Growth Spurs Partnerships and Economic Development

The Sandia Science & Technology Park (SS&TP) celebrated 20 years of growth and economic impact in 2018. A new report by the Mid-Region Council of Governments (MRCOG) showed that the SS&TP has generated $3.1 billion in economic activity and paid out over $5.4 billion in salaries since its inception.

Sandia National Laboratories Director Steve Younger joined Albuquerque Mayor Tim Keller at SolAero Technologies for a news conference announcing the results of the economic impact analysis.

"The SS&TP is a successful public-private partnership that has had a positive impact on the community," Younger said. "Sandia is committed to continuing to grow the Park through collaboration, bringing long-term, high-quality jobs and economic prosperity to the city, county and state."

Keller said the city is proud to be active in the Park which generates tremendous economic impact for Albuquerque and surrounding communities.

"The SS&TP has spurred growth in the Southeast Heights while providing a gateway to science and technology for our community," said Keller. "This Park is an example of a project that hits the mark on placemaking and ensures we're creating areas that will make our city succeed."

Speakers at the event noted the diverse public and private partners who championed the SS&TP and helped implement the vision for the Park.

Investments of over $384 million in the SS&TP have paid off handsomely. The Park has now grown to house over 2,000 employees working at 47 companies and organizations. It is home to engineers and researchers that support Sandia's technology transfer mission with partnerships between the Labs, community, and local industry. And the SS&TP continues to grow.

Albuquerque Mayor Tim Keller, Sandia National Laboratories Director Steve Younger, NNSA Sandia Field Office Manager Jeff Harrell, and SS&TP Executive Director Jackie Kerby Moore announcing the economic impact results.

New companies in the Park in 2018:

- Core Invention, Inc.
- Psigenics Corporation
- Xertrix Technologies, Inc

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

Converting Cow Manure into Biofuel and Economic Opportunity

Tucumcari Bio-Energy bought an abandoned ethanol plant in order to bring it back to life as a source of biofuel. However, instead of using corn to produce ethanol, the company will use cow manure to produce methane. To convert the manure into fuel, it will be mixed with water, whey left over from cheese production (a source of beneficial sugars and protein), and anaerobically digested in the facility's six 55,000-gallon fermentation tanks.

Bob Hockaday, Tucumcari Bio-Energy president, is using the New Mexico Small Business Assistance (NMSBA) Program to learn the best process for making methane from agricultural waste. In a 2017 NMSBA project, Sal Rodriguez, a nuclear engineer at Sandia National Laboratories, helped determine that the idea was feasible through the use of computational fluid dynamics. Modeling the slurry is similar to modeling liquid nuclear waste, and also helps improve modeling methods at Sandia. A 2018 NMSBA project defined the best operating mode including factors such as temperature and mixing, and studied slurry material properties such as pH and viscosity.

Once in operation, ranchers, farmers, and feedlot operators will be able to bring in their manure and in return get back sterile fertilizer and animal bedding. Cheese producers will gain a way to safely dispose of their waste for free, while Tucumcari Bio-Energy will sell the methane and carbon dioxide produced. This synergistic system can keep pollutants out of water resources, help farmers and companies save money on waste disposal, and produce cost-efficient renewable energy.

Tucumcari Bio-Energy is now talking to potential investors. Hockaday foresees the plant being able to produce $12 million in methane, carbon dioxide, and fertilizer each year. Next, his model could be replicated at defunct ethanol plants across the country.

Tucumcari Bio-Energy President Bob Hockaday stands in front of one of his company's large boilers.

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

Bringing Technical Data to Life with Analytics and Visualization

RS21 President and CEO Charles Rath holds a computer generated toy which represents the complexity his company seeks to understand and the beauty of their solutions.

Charles Rath was working at Sandia National Laboratories, using his background in public policy and analytics to help cities become more resilient. He noticed that wherever he went, from Bangkok to Boulder, there was a major disconnect between the vast amounts of available information and making it useful. Rath knew that good software, design, and data analytics can help people quickly grasp key points and take action, so he decided to start his own company to do that.

RS21 was launched in March 2015 when Rath left Sandia utilizing the Entrepreneurial Separation to Transfer Technology (ESTT) program. With its safety net features, ESTT made it much easier for Rath to sell the idea of entrepreneurship to his family. The program 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.

The company's rapid growth—there are now 50 people working for RS21—shows that it is filling a true market need at the intersection of art and science. He thanks local investors and mentors and is a strong proponent of utilizing local talent, creating high paying jobs in Albuquerque. A $2 million expansion was announced in September that will create 80 more jobs.

For Rath, early inspiration for data visualization came from graphic displays in sci-fi movies. But RS21 customers are solving real problems. The company is helping national laboratory researchers, businesses, and governments bring complex technical work to life by creating meaningful experiences for end users. This kind of data visualization can help first responders find vulnerable citizens who need assistance in a disaster and provide solutions to other socioeconomic problems around the world.

Sandians who left on ESTT in 2018:

- Cody Eilar, Lens (Startup)
- Cameron Ball, Uh-Oh Labs (Startup)
- James Ellison, Cimarron Power (Startup)
- Kyle Gaiser, Amber Kinetics (Expansion)
- Joseph Pratt, Golden Gate Zero Emission Marine (Startup)

Cultivating Partnerships with Programs at Downtown Location

The Center for Collaboration and Commercialization (C3), located in the Lobo Rainforest Building in downtown Albuquerque, was opened as a place where Sandia National Laboratories connects with the community. C3 programs and services, including the Entrepreneur Exploration (EEx) program, maximize interaction with industrial, academic, and government partners, and facilitate technology commercialization.

EEx is designed to invigorate an entrepreneurial culture at the Labs and help fulfill Sandia's technology transfer mission. Its goal is to inspire entrepreneurs to either enter the business world or develop a more entrepreneurial mindset within the Labs.

In its first year downtown at C3, the EEx program presented 22 events and launched several new initiatives. A quarterly Rainforest Speaker Series was begun in partnership with the Air Force Research Laboratory (AFRL), and a new EEx Livestreamed Webinar Series started.

EEx also hosted the National Labs Entrepreneurship Academy in collaboration with Los Alamos National Laboratory, AFRL, University of New Mexico, New Mexico State University, New Mexico Tech, and the State of New Mexico. This three-day entrepreneur training event was focused on the commercialization of lab-generated technology.

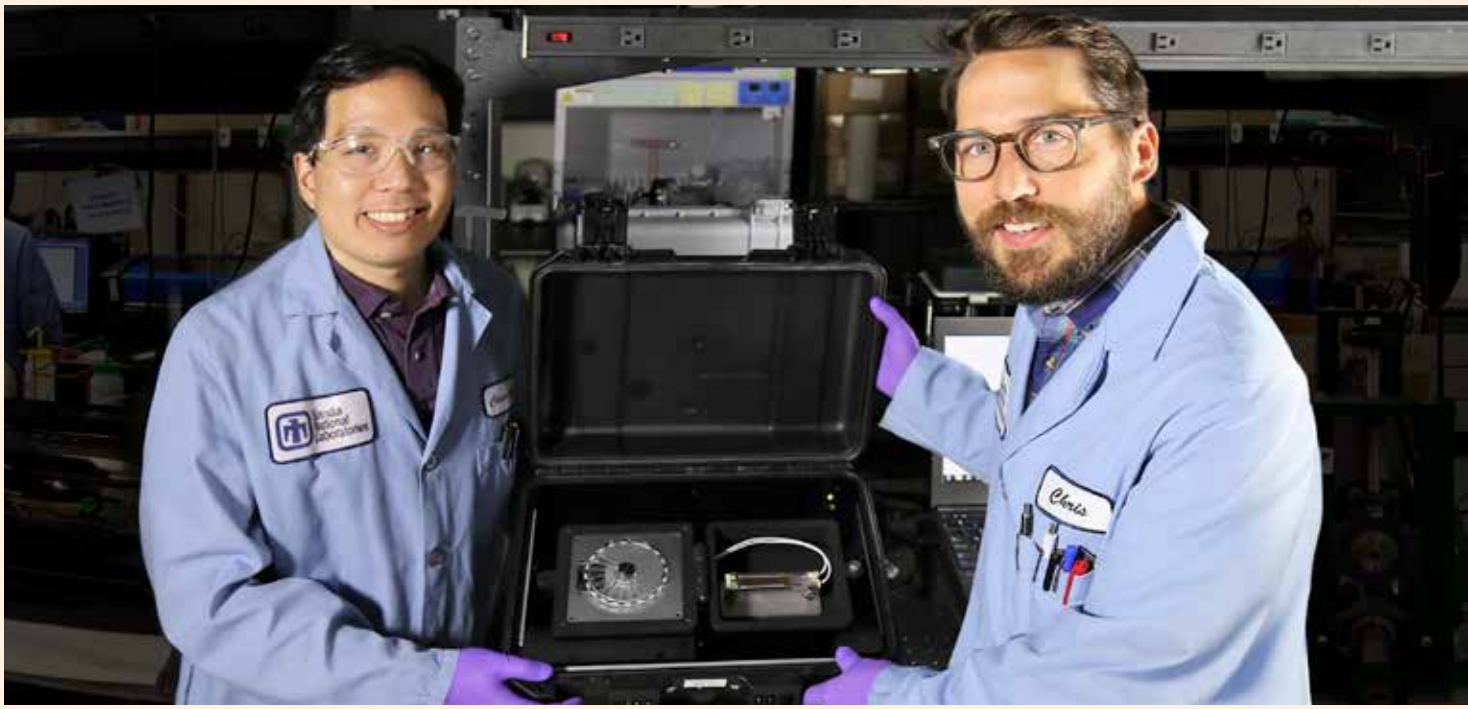
The second annual Sandia Pitch Competition was hosted at C3 in partnership with ABQid, a local organization that offers resources to startups. Presenters worked with mentors from industry and the entrepreneurial community to hone their pitches. The winning pitch was for Metalens, a new imaging technology to speed up DNA sequencing while reducing costs.

Meetings leading up to a CRADA signed between Sandia and Emera Technologies were arranged by Sandia staff at C3. Gary Oppedahl, Emera Technologies vice-president, said the location was vital to Emera being able to make connections with Sandia scientists and licensing executives. "Sandia is doing a variety of things to commercialize technology and C3 represents great outreach," said Oppedahl.

Sandian Adam Backer is the winner of the Sandia Pitch Competition at C3.

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

Collaborating to Solve Challenges and Build Capabilities



The Livermore Valley Open Campus (LVOC) is a portal to the national laboratories that supports collaborations with academia, industry, and international partners. Located on the eastern side of Lawrence Livermore National Laboratory and Sandia National Laboratories, California, LVOC is a joint effort of the two laboratories to incubate and grow partnerships in support of Sandia's national security mission.

LVOC programs include transportation energy, bio and life sciences, cyber security, high performance computing, and additive manufacturing. Researchers in the LVOC partner with industry, academia, and federal sponsors to collaboratively solve long-standing challenges facing the nation.

In addition to enabling new solutions to emerging and long-standing problems, these collaborations build the capabilities of the national labs, engage the workforce in challenging new opportunities, add to the pipeline of talented candidates to advance mission work, and establish a portal to the Bay Area innovation ecosystem for the laboratories.

LVOC partnerships are already producing value. The Combustion Research Facility (CRF)—an existing resource folded into the LVOC—has leveraged decades of collaborative research to create a scientific basis for improving engines. The CRF's contributions are perhaps best summed up by a top U.S. auto industry executive, who asserted that every engine made today is cleaner and more efficient due to the CRF's work.

Through the LVOC, Sandia successfully licensed SpinDx technology to multiple industry partners for uses as diverse as male fertility testing and water supply safety monitoring. An update to the technology now allows for rapid testing for both proteins and nucleic acid, making the device more useful in diagnosing infectious disease.

Overall, the LVOC enhances the flow of innovation by allowing for deep connections with diverse partners.

Sandia Chemist Chung-Yan Koh and former Sandia Bioengineer Chris Phaneuf hold the newly updated SpinDx diagnostic device.

To learn more about LVOC, visit lvoc.org

Minimizing Engine Soot Emissions with Ducted Fuel Injection

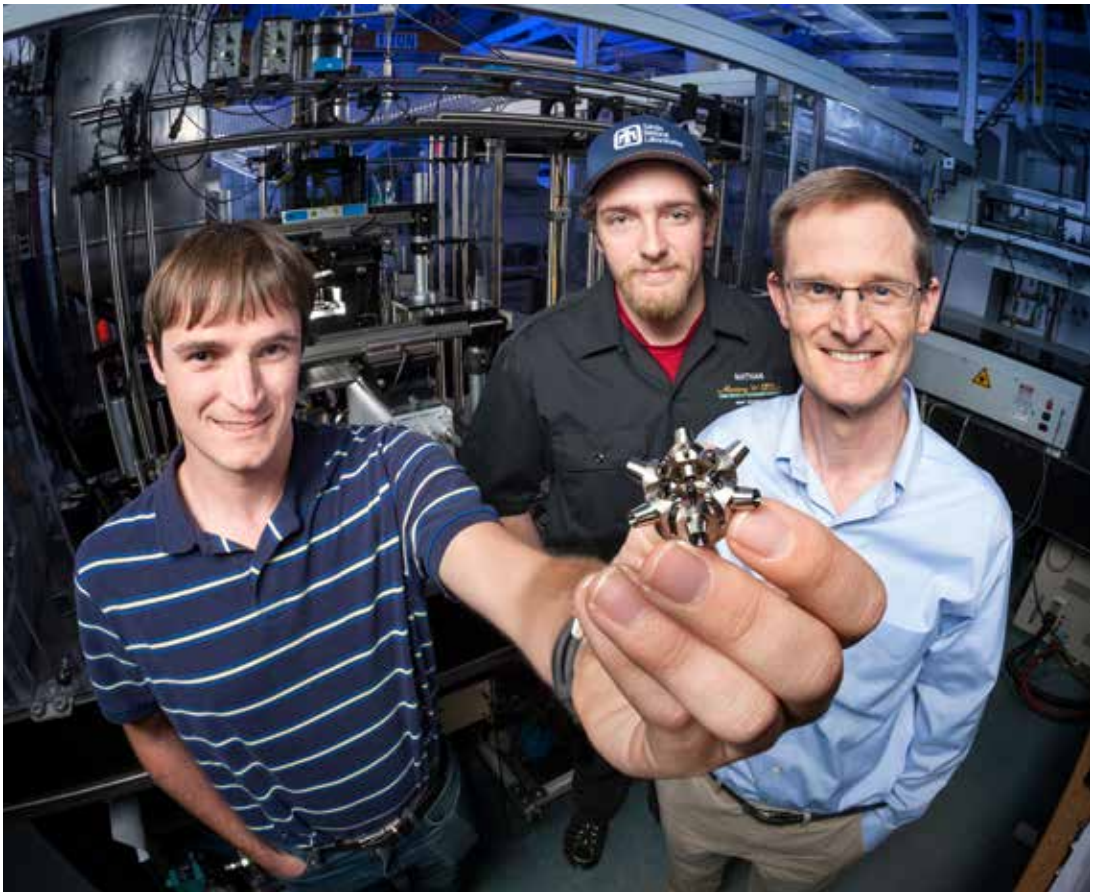
Ducted fuel injection (DFI) is a patented technology invented at Sandia National Laboratories' Combustion Research Facility that enhances engine combustion, lowering soot emissions while potentially enabling higher efficiency. It was designed to overcome the soot-NO_X tradeoff, a longstanding barrier to improved diesel-engine emissions. DFI enables soot emissions to be dramatically lowered without increasing NO_X emissions.

DFI involves injecting fuel along the axis of a small cylindrical duct within the combustion chamber. Passing each fuel spray through a tube enhances mixing to create stable flames that produce less soot than when fuel is sprayed unconfined into a chamber. Minimizing soot emissions may enable manufacturers to make exhaust-gas aftertreatment systems, like catalytic converters, smaller and less expensive.

DFI is synergistic with renewable, oxygenated fuels that can be produced in the U.S., resulting in less petroleum consumption and enhancing energy security. This can benefit the economy and the environment as carbon dioxide emissions are lowered.

Sandia was awarded a DOE Technology Commercialization Fund (TCF) project this year to advance research on DFI as a technology for the next generation of high-efficiency, fuel-flexible, clean, and cost-effective engines. Each energy-related TCF project pairs lab researchers with industry partners who are evaluating lab-developed technologies that fit their business models.

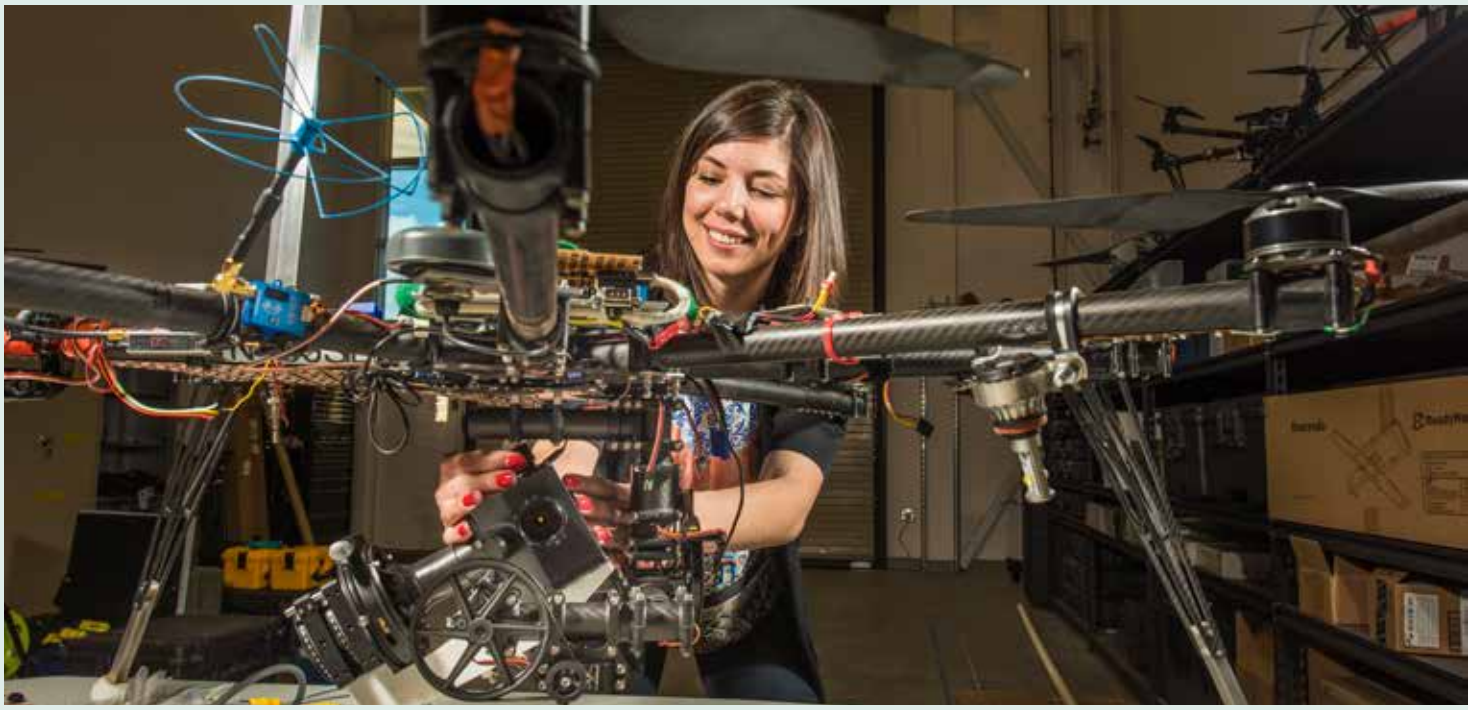
Sandia is working with industry partners Caterpillar, Inc. and Ford Motor Company on this TCF project. The team's comprehensive experimental facilities (including Sandia's advanced optical diagnostics), simulation tools, and careful analyses are being used to identify and overcome technical barriers to the commercial implementation of DFI. While DFI is currently being evaluated as a technology for heavy- and medium-duty diesel engines, in the future this technology also could be applied to gasoline, natural gas, and jet engines.



Sandia Researchers Christopher Nilsen (holding DFI duct assembly), Nathan Harry, and Charles Mueller in the Combustion Research Facility.

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

Finding Tech Transfer Opportunities Made Easier with New Apps



Sandia Optical Engineer Julia Craven works with optical remote sensing tools and techniques to solve problems in the nuclear nonproliferation and treaty verification mission spaces.

The Lab Partnering Service (LPS), which was launched in July 2018, 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. The three main applications are: Expert Search, a selection of lab-identified experts across hot technology areas; Technical 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 7 experts, 147 technical summaries, and 2,282 patents or patent applications available on the LPS website. Website visitors can search by technical market sector or keywords to find the experts with the knowledge they need.

Current Sandia experts are Julia Craven, an optical engineer in the Advanced Remote Sensing Department; Cliff Ho, a mechanical engineer in the Concentrating Solar Technologies Department; Mark Kinnan and Jeff Koplow, chemists engaged in a range of research activities on multidisciplinary projects; Christopher Long, who focuses on photonic devices; David Lord, a geochemist who currently leads the Crude Oil Characterization Research Study, and Sal Rodriguez, a nuclear engineer with expertise in computational fluid dynamics and energy systems.

Sandia received 14 inquiries from the LPS in FY18, resulting in several technical discussions. In these conversations, Sandians shared their expertise to help solve challenges, directed small business owners to commercially available tools to help develop their products, and discussed partnership opportunities.

In order to help expand the capabilities of the LPS, Sandia is developing a semiconductor facility search feature. The module will include information on relevant facilities at DOE national laboratories, enabling users find the one best suited to their research or production needs.

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

Exploring Advanced Manufacturing Solutions for LED Lighting

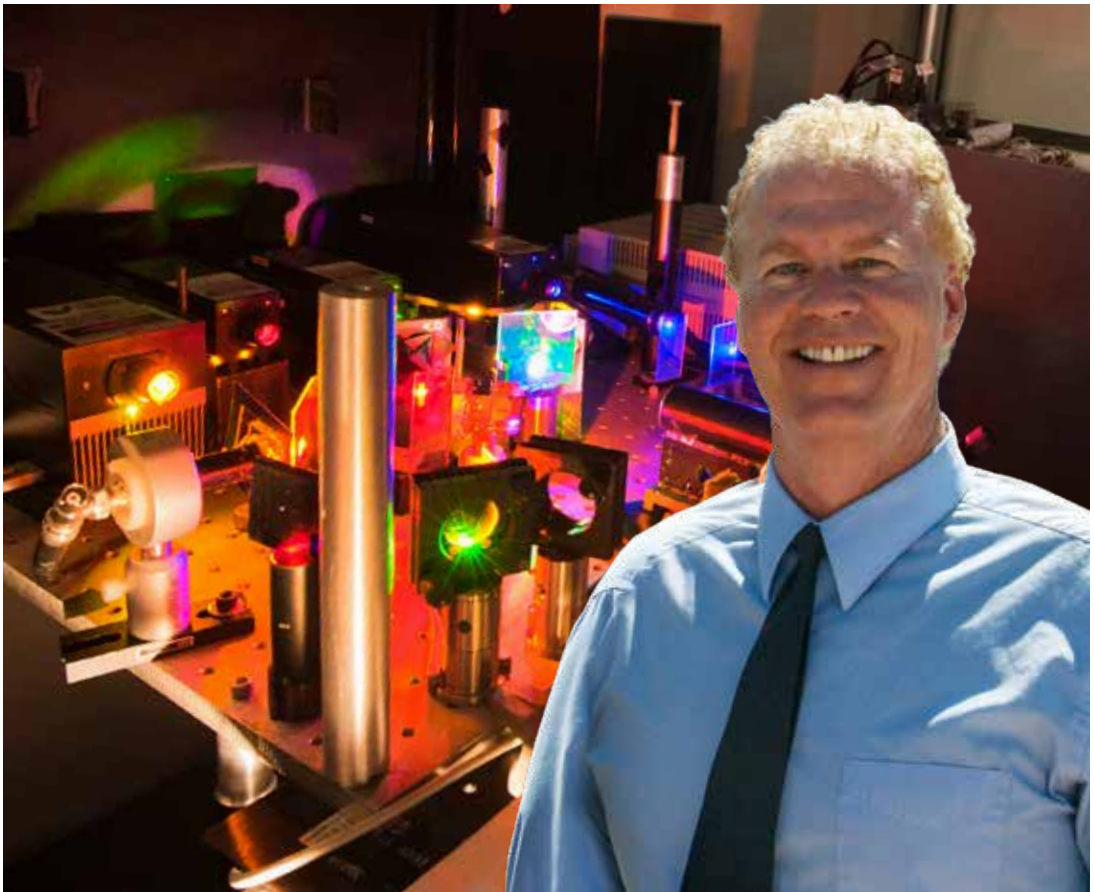
The Technologist in Residence (TIR) Program is a DOE Advanced Manufacturing Office (AMO) initiative designed to strengthen U.S. competitiveness. The program is designed to allow senior technical staff members from DOE national laboratories and manufacturing companies to work together towards long-term strategic collaborations and manufacturing solutions.

Sandia National Laboratories researcher Jeff Nelson was selected in a competitive process with semiconductor lighting chip manufacturer Lumileds to be one of the TIR Program funded pairs. Lumileds is a pioneer in high-performance light-emitting-diode (LED) chips and LED-based systems for lighting. Sandia has also made significant contributions to solid state lighting as an early thought leader through its Grand Challenge LDRD, *A Revolution in Lighting – Building the Science and Technology Base for Ultra-Efficient Solid-State Lighting,* and its Energy Frontier Research Center for Solid-State Lighting Science.

Together, Sandia and Lumileds are exploring semiconductor materials and devices for lighting and related applications. Their goal is to come up with new and manufacturable light sources with extremely small footprints coupled with high efficiency and novel added functionality. The solid-state lighting revolution is hardly over; it is just beginning, with many research and manufacturing challenges on the horizon.

Although Sandia and Lumileds have worked together over the years, the TIR partnership is a vehicle enabling them to invest greater effort in developing new research and manufacturing concepts that can be the basis for future collaborative R&D efforts.

Through the TIR Program, laboratories will gain greater knowledge of industry's concerns and industry will gain awareness of and access to a network of lab resources, facilities, and expertise that can support them. This is linked to the AMO's core objective of increasing U.S. competitiveness in advanced manufacturing technologies.



Sandia Technologist in Residence Jeff Nelson.

To learn more about the TIR, visit https://www.energy.gov/eere/amo/technologist-residence-program

Innovation and Intellectual Property Celebration

Sandia National Laboratories' Integrated Partnerships Organizations hosted the 9th annual Innovation and Intellectual Property Celebration on December 6, 2018. The annual event honors the innovative culture and intellectual property generated by Sandia's scientists, engineers, and technologists.

Awards were given to 165 inventors for granted patents in calendar year 2017 and 68 copyright authors for copyrights asserted in calendar year 2017. The event also recognized 33 Mission Innovators, who were nominated by their divisions for innovation in support of Sandia's national security missions.

Awards were also presented to 18 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' intellectual property portfolio.

NMSBA Innovation Celebration

Projects that achieved outstanding innovations through the New Mexico Small Business Assistance (NMSBA) Program in 2017 were honored at an Innovation Celebration in 2018.

Three of these projects received technical assistance from Sandia. The Altree Leveraged Project received test data that enabled an updated version of their wood/recycled plastic composite to be used in new product applications. Tucumcari Bio-Energy used data from technical research to apply for loans to reconfigure an idle ethanol plant to convert animal manure to biomethane. Voss Scientific added new customers and increased annual sales after technical assistance improved the performance of their CP-560 sensor. The Geometric Dimensioning and Tolerance Courses given by Sandia since 2000 were also recognized.

One leveraged project received the *Honorable Speaker Ben Luján Award for Small Business Excellence* for demonstrating the most economic impact. Safe Quantum Dot Materials for Solid State Lighting has received Small Business Innovation Research grants from the DOE and National Science Foundation, as well as a grant from Breakout Labs. The companies involved in this project have also received $1 million in investment funds and made new hires.

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.

R&D 100 Awards

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

Detergent-Assisted Fabrication of Multifunctional Nanomaterials LDRD
Ordinary detergents can produce uniform sizes and shapes of multifunctional materials at the nanoscale, boosting their performance for use in applications from environmental cleanup to cancer treatment.

LAMMPS: Atomistic Simulation of Materials LDRD
A widely-used molecular dynamics simulation package that models materials from the atomistic to continuum scales. It can run on desktops or supercomputers to explore the structural and dynamic properties of materials.

Large Field-of-View Bench-Top 3-D X-Ray Phase Contrast Imaging System LDRD
The system makes it possible to image low-density materials, such as the human body, polymers, epoxies, fillers, foams, and plastics with as much as 1000 times more sensitivity than X-ray imaging.

Power API
A standardized interface for power measurement and control for all types of computing systems won in the IT/electrical category and received a special recognition for corporate responsibility.

SWiCK Zoom LDRD
A true optical zoom method that requires low power and no macroscopic parts to achieve millisecond-timescale changes to optical resolution and field of view. (Co-developing organization: Naval Research Laboratory.)

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

Advanced Nanomaterials for Energy Conservation and Temperature Regulation LDRD
IR Dynamics is working with Sandia to create tunable thermochromic nanoparticles triggered by the environment to control solar heat gain. The nanoparticles can be incorporated into windows, architectural plastics, and athletic clothing.

Technology Focus Award

Successful Collaboration Accelerates Testing of New Blade Designs
Sandia, Oak Ridge National Laboratory, and TPI Composites demonstrated a way to produce prototype wind blade turbine blades using 3D printing to speed up the process and cut costs.

FLC Mid-Continent & Far West Region Awards

Technology Transfer Professional of the Year

Jason Martinez
Business Development Specialist Martinez was honored for strengthening the Labs' Cooperative Research and Development Agreement strategy and significantly growing the CRADA portfolio three years in a row.

Regional Partnership

Sandia and Goodyear Partnership: How Simulation is Key to Designing Tomorrow's Tires LDRD
Twenty-five-year partnership with The Goodyear Tire & Rubber Company has produced many successful projects and advances for the tire industry and Sandia.

Outstanding Partnership

SUMMIT Partnership
Sandia and partners were recognized for the deployment of the Standard Unified Modeling, Mapping and Integration Toolkit (SUMMIT) for emergency planners and first responders.

Technology Development

Organic Glass Scintillator LDRD
Advances in the science of scintillators — objects that detect nuclear threats — through the development of organic glass.

Other Awards

Southwest Region Economic Development Association Awards

Star of the Southwest

Sandia Science & Technology Park was recognized for its 20 years of economic growth. All of the winning projects were funded, in part, through support from the U.S. Economic Development Administration's Austin regional office.

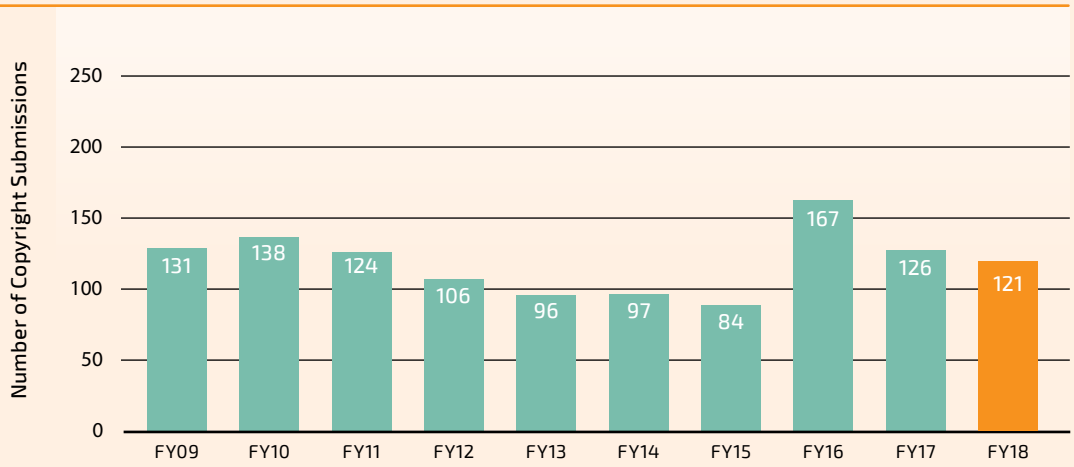
DOE Technology Transfer Working Group Awards

Best in Class for Economic Development

Genaro Montoya was recognized for successfully leading two programs, New Mexico Small Business Assistance and Entrepreneurial Separation to Transfer Technology.

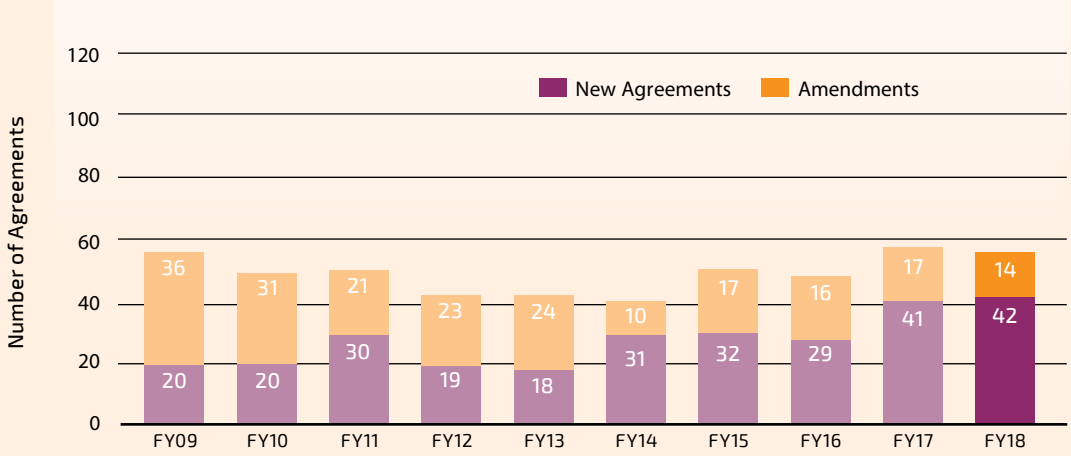
Copyrights

Copyright Submissions

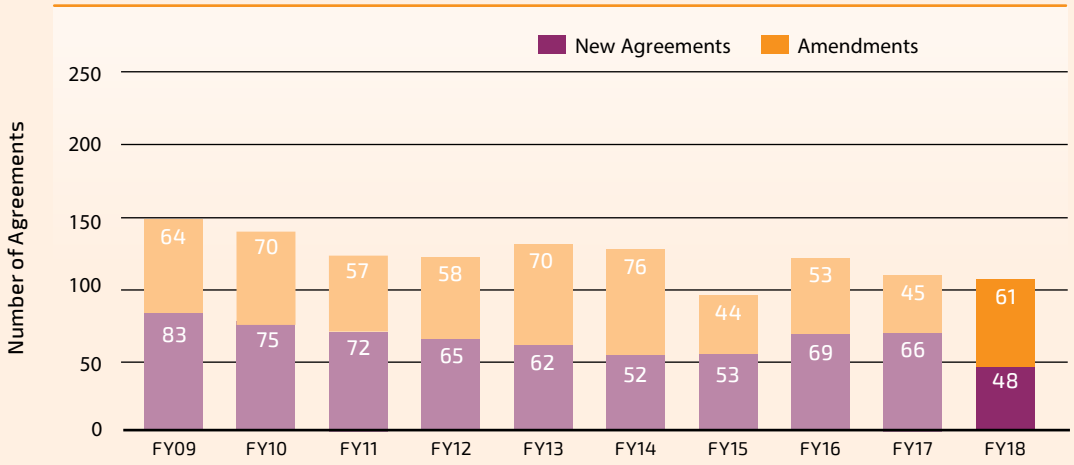


CRADAs and SPP/NFE Agreements

Cooperative Research and Development Agreements (CRADAs)

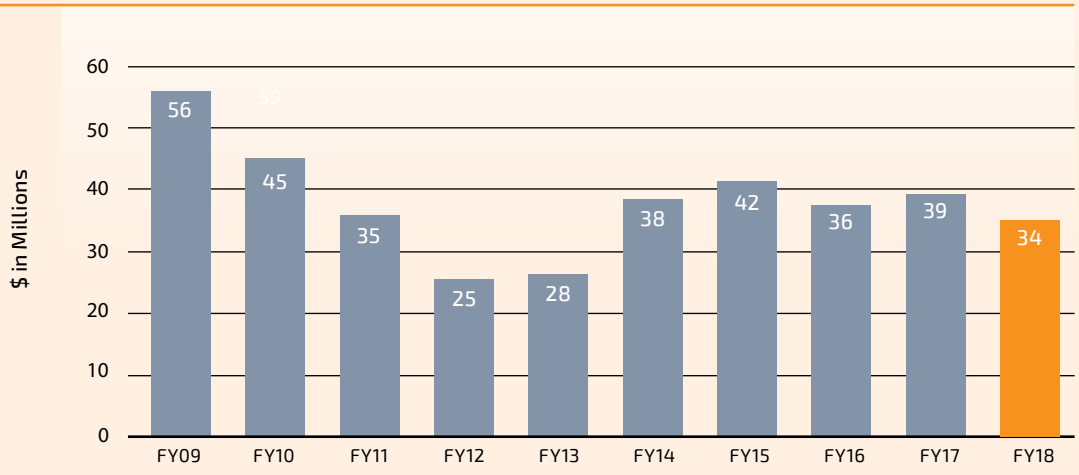


Strategic Partnership Projects/Non-Federal Entity (SPPs/NFE) Agreements



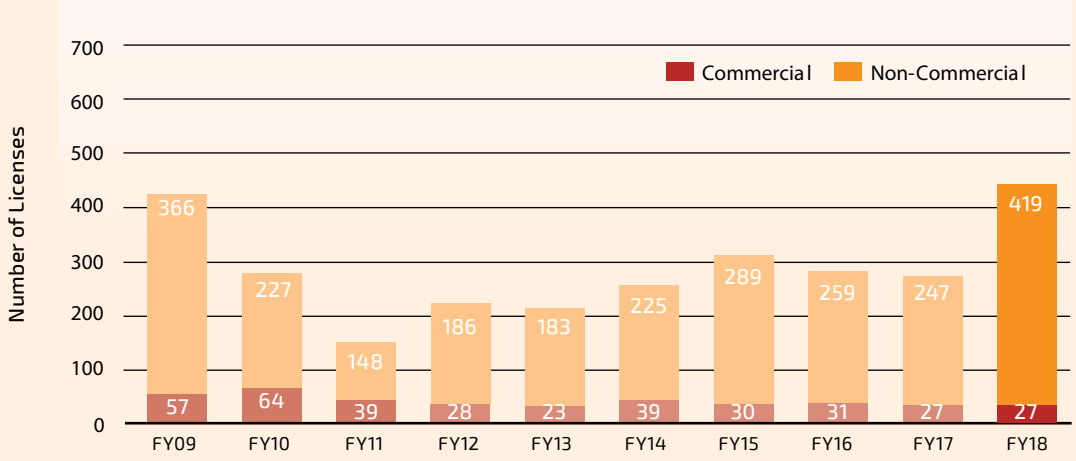
Industry Funds-In

Industry Funds-In to Sandia ($M)

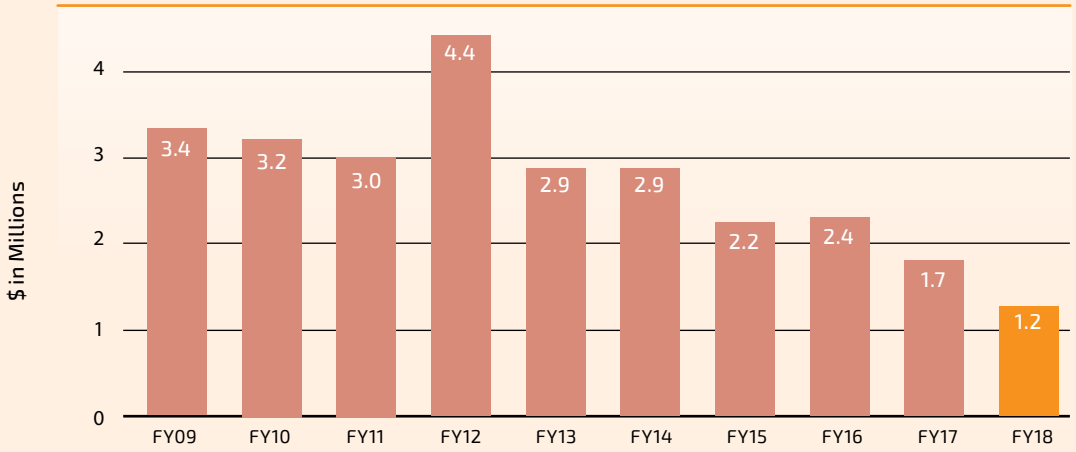


Licenses

Licenses

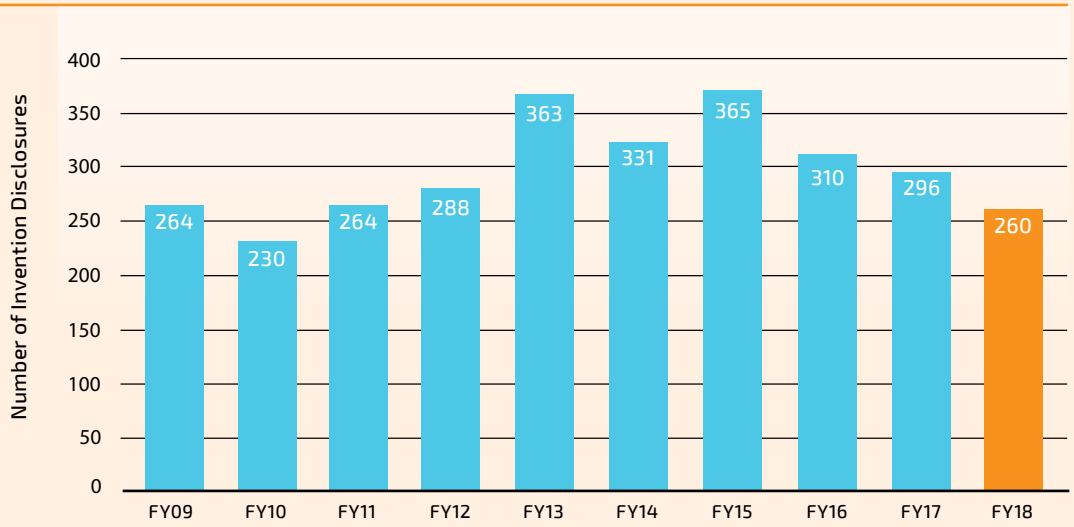


Licensing Income ($M)

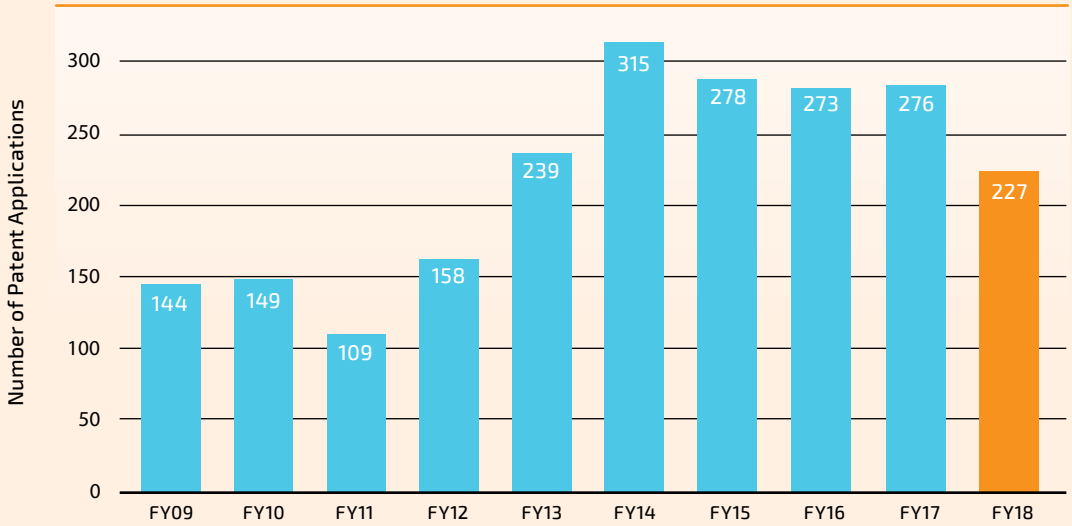


Patent Activity

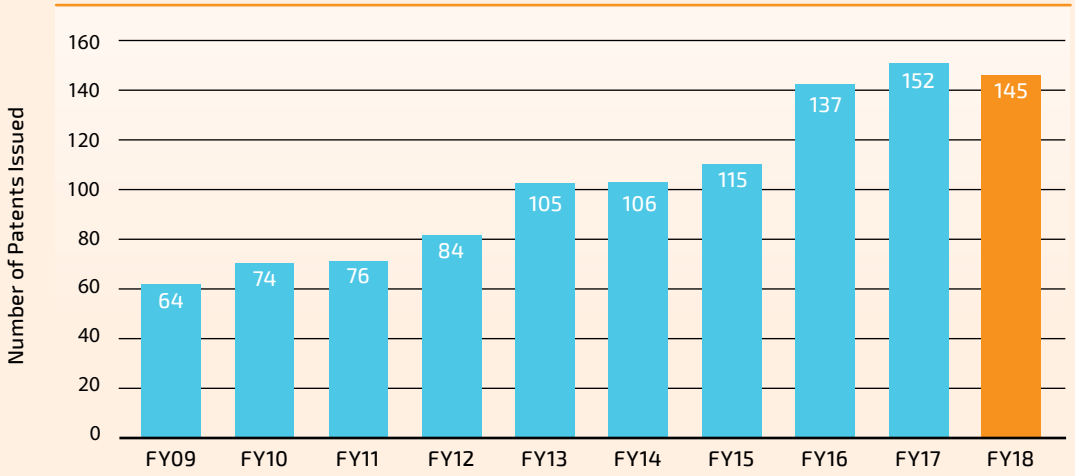
Invention Disclosures



Patent Applications



Patents Issued



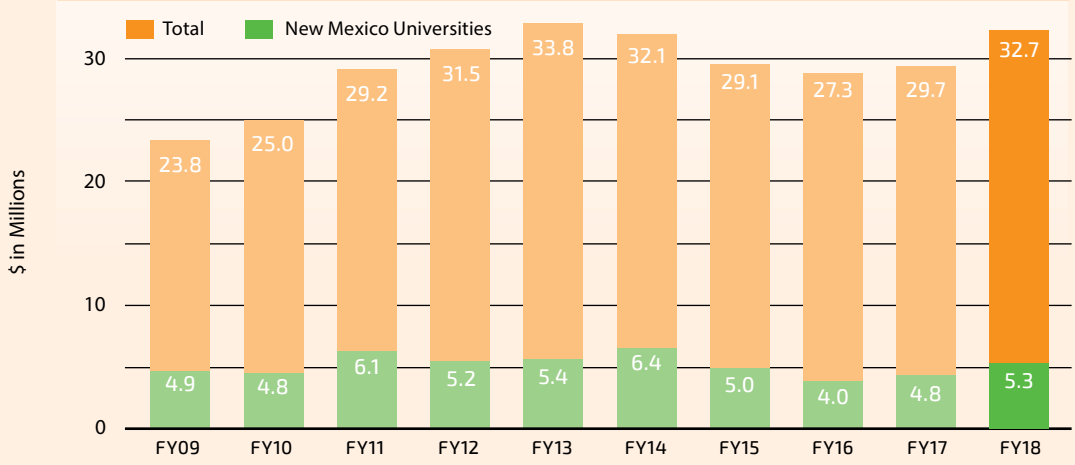
University Partnerships

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 Academic Alliance 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.

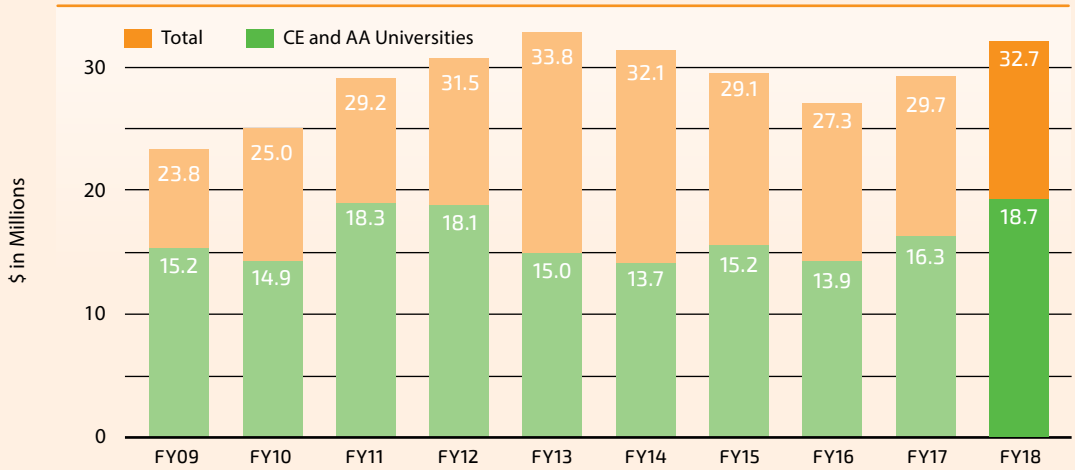
The University Partnerships Office, under the auspices of the Chief Research Officer, serves as the point of contact for university research issues and implements those processes that enable university partnerships. In 2018, a New Mexico partnerships manager was added along with several staff members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

Investments in Research at New Mexico Universities



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

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



SCORECARD

Sandia Science & Technology Park (SS&TP)

Companies and Organizations	48
Employees	2194
Buildings	26
Public Investment in the Park*	$89.0M
Private Investment in the Park*	$300.6M
Total Investment in the Park*	$389.6M
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.*

2018

Results from the economic impact assessment covering the past two years showed $747.7M in wages, $388.7M of taxable personal consumption, and $15.4M in tax revenue to the State of New Mexico and $6.6M to the City of Albuquerque.

SANDIA SCIENCE & TECHNOLOGY PARK

New Mexico Small Business Assistance (NMSBA)

	Sandia: 2000-2018
New Mexico Small Businesses Assisted	2263
Rural vs Urban Businesses	
Rural (61%)	1373
Urban (39%)	890
Combined	2263
Dollar Amount of Assistance	$38.8M

	Sandia and Los Alamos: 2000-2017*
Return on Investment (ROI)**	$1.43
(For every $1.00 of state tax credit invested)	
Economic Impact	
Small Business Jobs Created and Retained	7835
Average Reported Salary (2017)	$52K
Increase in Revenue	$378M
Decrease in Operating Costs	$183M
Investment in NM Goods/Services	$133M
New Funding/Financing Received	$149M

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

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

2018

Sandia invested $2.4M helping 187 small businesses in 22 counties throughout New Mexico. There were 68 Sandia principal investigators across 54 departments that supported NMSBA.

NMSBA
Los Alamos National Laboratory
Sandia National Laboratories

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.*

2018

Five employees took the skills and expertise they acquired at Sandia and left on ESTT. Four left to start small businesses and one left to expand an existing business.

ESTT
Entrepreneurial Separation to Transfer Technology

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

Events	68
Participants	3319

**Since EEx began in 2015.*

2018

EEx held 22 entrepreneur events with a total of 1256 participants.

CENTER for COLLABORATION and COMMERCIALIZATION
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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NNSA National Nuclear Security Administration
U.S. DEPARTMENT OF ENERGY

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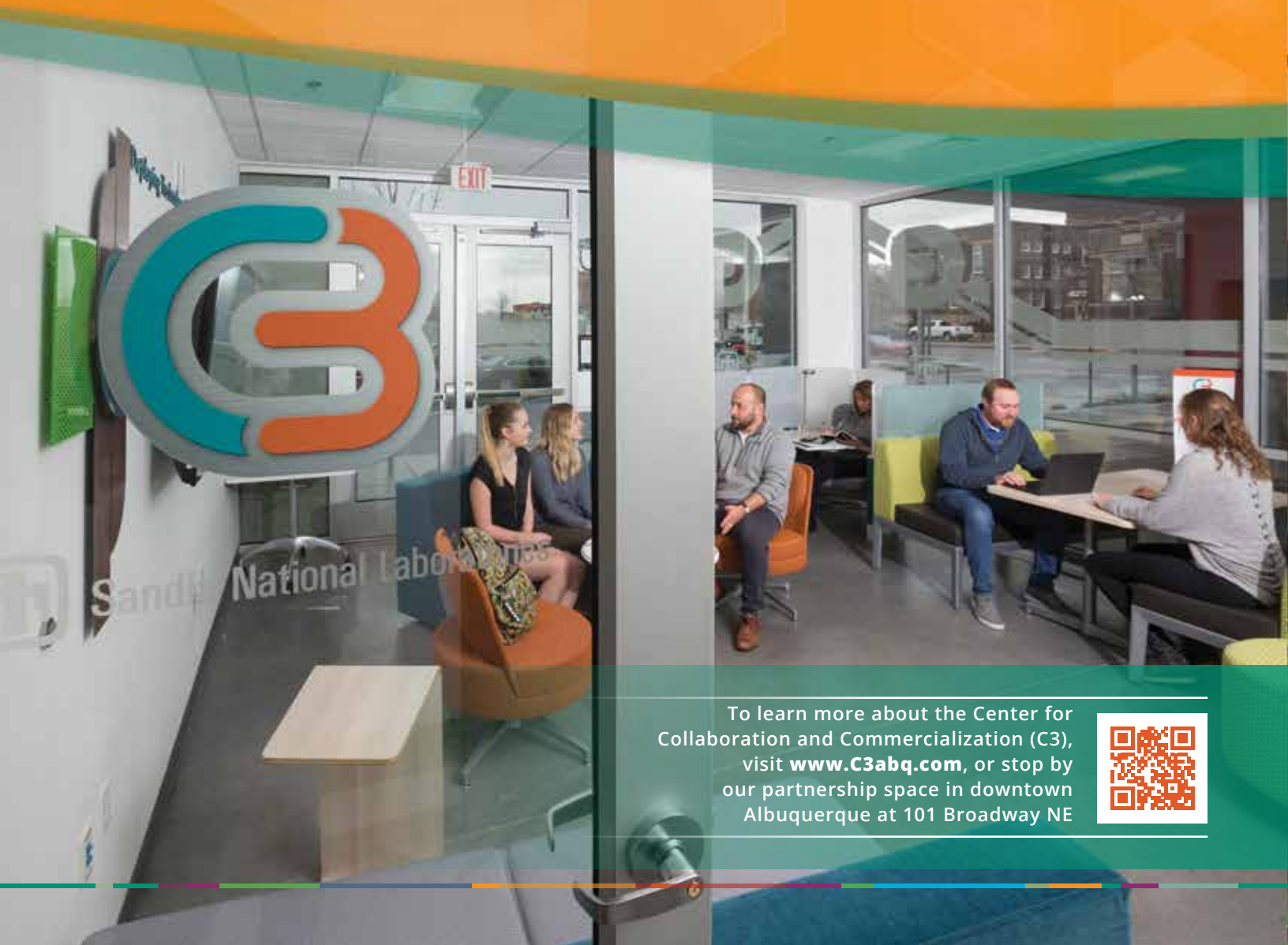
IPO Integrated Partnerships Organizations

To learn more about industry or university partnership opportunities with Sandia, visit **www.sandia.gov/partnerships** or contact us at 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

Small Business First

To learn more on how to do business with Sandia, visit **http://sbu.sandia.gov** or contact us at supplier@sandia.gov



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