National Nuclear Security Administration

Sandia National Laboratories

SUCCESS STORIES

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National Nuclear Security Administration
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Success Stories

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Essential funding from the Department of Energy, the NNSA, and Sandia ripples out through the global economy, creating jobs, encouraging innovation, and benefitting Warfighters.

MODELING THE FUTURE

DAKOTA software provides state-of-the-art tools for improving technologies through computational analysis and design

When building a new technology or improving an existing one, having the ability to make design modifications and test the outcome is essential to future success. That's why Sandia National Laboratories' cutting-edge modeling software, DAKOTA, has become such a critical tool for designers, scientists, and national security officials around the world. Sandia is a subsidiary of Honeywell International, Inc., and is operated as a management and operating contractor for the Department of Energy's (DOE) National Nuclear Security Administration (NNSA).

DAKOTA had modest beginnings. Sandia researchers began working on the software in the mid-1990s as an internal R&D project at Sandia focused on optimization methods—calculating the best model parameters to minimize cost, maximize performance, or simply meet certain requirements. As computing power increased, so did DAKOTA's capabilities. A few years after its initial development, the Albuquerque, New Mexico-based research and development center added what would become one of DAKOTA's central tools: uncertainty quantification.

Michael Eldred, a distinguished member of the technical staff with Sandia, explains uncertainty quantification as an essential element for modern technology design. With it, scientists can account for intrinsic variability that can adversely affect product performance. When neglected, this variability can negatively impact robustness and reliability, and lead to products that may perform poorly or become unsafe. But by including the impact of these uncertainties within the development process, products can be designed to be both effective and reliable.

"In an uncertainty quantification (UQ) problem, you have random input variables that can be described by a probability distribution," Eldred said, using examples of an uncertain operational environment, such as wind speed and temperature. "These random input variables have to propagate through your computational simulation in order to translate to corresponding distributions on output quantities that define essential performance metrics, such as lift and drag."

This type of modeling requires high amounts of computing power and, in some cases, lots of time. What Eldred calls "hero-scale models"—ultra-complex high-fidelity simulations such as earth-system climate models—can take weeks to compute a single solution even on the largest computers currently available. This leads to a central challenge for the DAKOTA project—enabling the use of extreme-scale simulations within processes that must quantify the effects of variability over a wide range of possible scenarios.

The DAKOTA software itself is open source and freely available to use, a decision Sandia made in order to better support a diverse and expanding user base that includes industry, universities and government agencies around the globe, and supports interactions ranging from research collaborations to production deployments. According to one measure, more than 25,000 users worldwide have downloaded the software since January 2010.

"Being able to openly share the software really facilitates these interactions," Eldred said, "and allows us to develop more of a community around these important problems."

Many of DAKOTA's early adopters came from the world of national security, which is where the program, "grew from an internal R&D investment into something that provides real impact on our missions," according to Eldred. In particular, NNSA's Advanced Simulation and Computing Initiative program was among the first to recognize verification, validation (V&V), and UQ as essential parts of computational simulation. This drove both DAKOTA's early investments in UQ and the demonstration of these approaches within NNSA applications.

Sandia is focusing on multiple tracks: investing in foundational algorithm research, improving the technology's user interface to make it more usable and accessible, and investing in scalable techniques for next-generation computing platforms.

Another recent trend has been rapidly expanding interest from programs in DOE's Office of Science such as CASL and SciDAC, with applications ranging from nuclear and wind power to climate modeling, computational materials, and quantum chemistry. Optimization and UQ are broadly applicable enabling technologies, and the early investments by NNSA are having broad return both across DOE and elsewhere.

In addition to internal DOE missions, DAKOTA has demonstrated impact within a number of industrial partnerships spanning such diverse areas as aerospace vehicles, film coatings, and tires. These partnerships are formalized as Cooperative Research and Development Agreements, or CRADAs. In one instance in 2006, researchers from Sandia and Lockheed Martin applied DAKOTA's optimization methods to design the external fuel tank for the F-35 Joint Strike Fighter aircraft. In particular, the toolkit enabled a "virtual prototyping" design process to refine the fuel tank shape, replacing a number of expensive wind tunnel tests with a simulation-focused approach. Subsequent test data then validated the predicted performance of the new aero-shaped fuel tank for low observability (i.e., stealth), fuel efficiency, and flight safety. Other domestic partnerships included Goodyear—which used DAKOTA as well as other Sandia software to, in Eldred's words, "modernize the computational modeling of tires in order to enhance their international competitiveness." 3M and Kodak used DAKOTA to optimize thin film technology, and Caterpillar, which designs heavy machinery, used DAKOTA in its computational approaches. The software has also been part of international collaborations, with companies like BMW and universities such as the Technical University of Munich.

"Balancing the competing needs of generality and usability is an important challenge for us," Eldred said. "We want to be able to support these types of studies using any simulation under the sun, but at the same time, make it straightforward to use in a diverse range of scenarios."

One of the software's main drivers has been the DOE and the NNSA. Established by Congress in 2000, the NNSA is a semi-autonomous agency responsible for enhancing national security through the military application of nuclear science. Among its many duties, the agency maintains the U.S. nuclear weapons stockpile; works to reduce the global danger from weapons of mass destruction; provides the U.S. Navy with safe and militarily effective nuclear propulsion; and responds to nuclear and radiological emergencies in the United States and abroad.

Michael Eldred

"Much of the organization's day-to-day work involves the monitoring and maintenance of the country's nuclear stockpile," said Jahleel Hudson, the executive director of the NNSA's Office of Strategic Partnership Programs. This means a lot of testing—flight tests, non-nuclear component tests, benchtop tests, and many others. However, since there has not been a nuclear weapons test since 1995, much of the modern study requires


Photo Courtesy Sandia

Developing technology as complex as the cutting-edge DAKOTA modeling software takes an entire team of essential, highly qualified personnel.

taking older testing data and using it to support V&V and UQ processes, such as those enabled by the DAKOTA software. These simulations and calculations can ultimately ensure that NNSA technology is effective and working as intended.

Hudson compares the work to building a car. "Imagine if you made a car engine with whatever mechanical and chemical parts needed and had to certify it could run without being able to start it," he said. "This means that practical simulations and accurate theoretical calculations are extremely important."

DAKOTA has provided both of those in spades, Hudson said, allowing the NNSA to both improve the design of nuclear weapons as well as run scenarios that help modernize the current stockpile. Considerations such as the environment and unexpected occurrences such as natural disasters all play a factor in determining the safety and longevity of the stockpile.

"These are chemical reactions, and they're not stable. One must evaluate the duration that they can be maintained," he said. "Using DAKOTA, you can investigate different reactions and determine the best course of action after evaluating all the scenarios."

With computers continuing to become more powerful and exascale computing on the horizon, the future is bright for the DAKOTA software, according to Eldred. Sandia is focusing on multiple tracks: investing in foundational algorithm research, improving the technology's user interface to make it more usable and accessible, and investing in scalable techniques for next-generation computing platforms.

"We're trying to expand in each of those areas to make DAKOTA more impactful," Eldred said. "I'm excited for the future of how we'll be able to interact with the new computing facilities coming online. We're hoping it will be a home run."

SMELL TEST

New Mexico company turns Sandia-licensed chemical sensors into commercial equipment

In the early 2000s, the U.S. military was in search of a simple, effective way to remotely monitor an area for chemical or biological agents. Even though the technology behind unmanned aerial vehicles (UAVs) was still in its infancy, scientists and engineers nevertheless saw UAVs as a potential solution.

In 2003, Sandia National Laboratories (Sandia) partnered with Lockheed Martin using a Cooperative Research and Development Agreement (CRADA) to develop a minimal power, lightweight technology that could be attached to drones in order to check for potentially harmful chemical agents from a safe distance. The resulting tech—called SnifferSTAR—was built with Sandia's assistance, under Lockheed Martin's Shared Vision Program and aided by numerous CRADAs.

Douglas Adkins helped lead the effort from Sandia's side. While there were certainly other gas monitors around, the weight, power consumption, and rapid analysis of the SnifferSTAR made it a novel piece of technology. Quick readings are extremely important in a battlefield or emergency-type scenario where time could make the difference between safety and potential danger.

"This is small, lightweight, low power, and offers rapid analysis," Adkins said at the time. "Rapid analysis currently is not possible with any other package near this size."

The invention itself consists of a group of small sensors mounted on a postage-stamp size platform, which is itself mounted on a credit-card size microprocessor board. The entire device weighs less than a golf ball and needs only a half-watt of electrical power to run. Once mounted to a device such as a UAV, movement forces air through the sensors, which absorb it, concentrate it, then release it onto thin strips of coating materials. Those strips are located on a surface that vibrates based on the amount of particles collected. The vibration frequencies are then compared to a library of patterns created by a range of gases in order to determine the chemical or biological makeup of the air.

The device can repeat the sampling process every 20 seconds, feeding data to a processing unit located on the drone or linked to a separate unit on the ground.

SnifferSTAR was an instant hit, winning a coveted R&D 100 Award and receiving positive press from mainstream media outlets, particularly in light of conflicts in Iraq and Afghanistan. But Adkins said that while he recognized its national security applications, he always felt the technology had untapped commercial potential as well.

In 2005, Adkins left Sandia to form a new company—Albuquerque, New Mexico-based Defiant Technologies. From its early days, the small business focused on

Defiant Technologies, Inc.

The Air Frog-200 (previous page) and the Frog-5000 (left) from Defiant Technologies represent the latest in remote-monitoring technology for chemical or biological agents.

environmental contamination work, specifically helping to monitor water quality and detect potential contaminants in water, soil and air. For Adkins, there was plenty of overlap between his previous work at Sandia—and with SnifferSTAR in particular—and what Defiant was doing. So when the opportunity arose to form a licensing agreement with Sandia for some of the second-generation SnifferSTAR tech, it was an immediately symbiotic relationship.

"We went to Sandia and licensed some of the technology that they had developed," Adkins said. "At the time it seemed daunting, but in hindsight it was simple."

Using the SnifferSTAR tech, Adkins and his business partner Pat Lewis adapted the micro-fabricated sensors components into the company's own commercial chemical detection equipment, called FROG. Equipped with a glass collection bottle, the portable gas chromatograph can detect in real-time volatile organic compounds (VOCs) in water and soils down to part-per-billion level concentrations.

"Labs take technology 30 percent of the way to commercialization, but then there's the other 70 percent. That's where our expertise comes in," Adkins said. "The SnifferSTAR technology was an important part in starting up, but taking it from there to a commercial product like FROG was where we at Defiant could be effective."

FROG has been useful for a varied clientele domestic and abroad, including consultants, the construction industry and environmental organizations and agencies.

In one instance, the New Mexico Environment Department utilized FROG to determine benzene levels in soil at a leaking underground storage tank that was also contaminated with fuel products. A handheld photoionization detector (PID) was giving the agency false positive readings due to the hydrocarbon contamination, but the FROG's accuracy and reliability reduced the volume of soil that would have been removed using only the PID, resulting in the savings of time and money.

While Defiant continues to improve the sales and distribution of its detection equipment, Adkins said that initial licensing agreement allowed the company to hit the ground running.

"We have good products and they have filled a niche," Adkins said. "It's a great example of why there are a lot of companies out there that want to license government IP."

WHERE THE RUBBER MEETS THE ROAD

The Goodyear Tire & Rubber Company collaborates with Sandia National Laboratories on simulation code

The story of how a United States' national security lab and a tire company forged an unlikely relationship begins with the perfect storm. In 1989, as part of a mission to strengthen the country's commercial industry, Congress passed the National Competitiveness Technology Transfer Act, which tasked the Department of Energy (DOE) with bringing technology created in national labs to commercial companies. The appropriations gave DOE research labs the funding to help U.S. industry solve some of its biggest problems, while further developing mutually beneficial technology.

"Tech transfer was an exciting new opportunity for the labs," said Mary Monson, senior manager of Technology Partnerships at Sandia National Laboratories. "The Department of Energy really embraced the tech transfer concept for federal agencies in the late 1980s and early 1990s. Part of the budget from the Office of Defense Programs within NNSA was put aside for U.S. economic security for the nation, as well as enhancing the capabilities of the labs through solving complex real-world problems. Labs identified their capabilities and were authorized to collaborate with partners."

One of the major technological services the DOE had to offer companies was the ability to parallelize analysis codes. That meant building the capacity for a company's computers to execute multiple functions at a time rather than slowly, one after the other. The Goodyear Tire & Rubber Company took note of the opportunity, and in 1992, sent one of its research engineers to Sandia to investigate.

The U.S. government labs seemed like a good place to look for help to keep up with technological advancements in the global industry. The ability to run analysis codes in parallel seemed like a step in the right direction.

After visiting Sandia, however, Goodyear's engineer reported back that there was a lot more to this opportunity than code parallelization. The potential for a collaboration between Goodyear and the DOE was, in fact, vast. There were some surprising similarities between the design codes Sandia was using to apply to nuclear weapons systems and the design software a company like Goodyear might need for developing tires. And that same year, in 1992, President Bill Clinton had put a moratorium on nuclear testing that would later result in the 1996 Comprehensive Nuclear Test Ban Treaty, which prohibited any nuclear weapon test explosion. That meant that Sandia could no longer rely on nuclear testing. If it was going to maintain the nuclear weapons stockpile, it would need to do it through high-tech simulation.

Still, it would take some innovative, outside-the-box conversation to answer the strange question: How would a nuclear weapons lab and a commercial tire company productively collaborate?

Both Goodyear and the NNSA had issues to solve. The tire company, for instance, was facing bottlenecks in its development of new tire products. Histor-

Photos Courtesy Sandia National Laboratories

Empowered by CRADAs, the partnership between Sandia and Goodyear worked to the mutual benefit of both organizations.

ically, new tires were developed by creating a design concept, building a prototype, and then testing it in the lab and on the road.

"Typically it could take three years to develop a new tire design," said Thomas Ebbott, R&D Fellow for Modeling and Simulation at Goodyear. "The design-build-test cycle is complex, lengthy, and expensive. Significant resources are dedicated to experimental tire building and testing."

This three-year process of developing tires had worked in the past, but was becoming outpaced in a faster, more competitive world. Something needed to change.

Sandia had been developing a suite of simulation codes with capabilities for thermal, fluid aerodynamics, solid mechanics and structural dynamics. The code incorporated models relevant to a broad swath of applications, including both weapons and tires.

"The codes incorporate broad concepts of physics," Ebbott said. "Concepts like Newton's Laws and conservation of energy are fundamental to mechanics. There are certain things that are special in tires that weapons don't need and there are certain things in nuclear weapons that tires don't need. But the basic mechanics portion of it is the same for both."

To collaborate, Sandia and Goodyear signed a Cooperative Research and Development Agreement (CRADA) to combine resources and accelerate the process of developing the codes. The CRADA allowed both parties to work on experimental and computational projects, while giving Goodyear the ability to use the codes without the licensing constraints often associated with commercial software codes.

In the early 1990s, this kind of mutual agreement between a government agency and a company with non-defense related goals was unusual. It took some negotiation to figure out how it might work, but eventually the common interests between parties allowed for a signed agreement. For almost 30 years, Sandia and Goodyear have continued this partnership through the signing of more CRADAs in service to an ever-evolving design code.

For the tire company, the outcome has been an ability to accelerate its product development, and to explore hundreds of designs at a time rather than just a handful. The technology works using numerous inputs. That means inputting information about the materials, the geometry, and the conditions related to the tires. Those inputs can be tweaked and tested in simulation until the company's engineers are able to create a new tire.

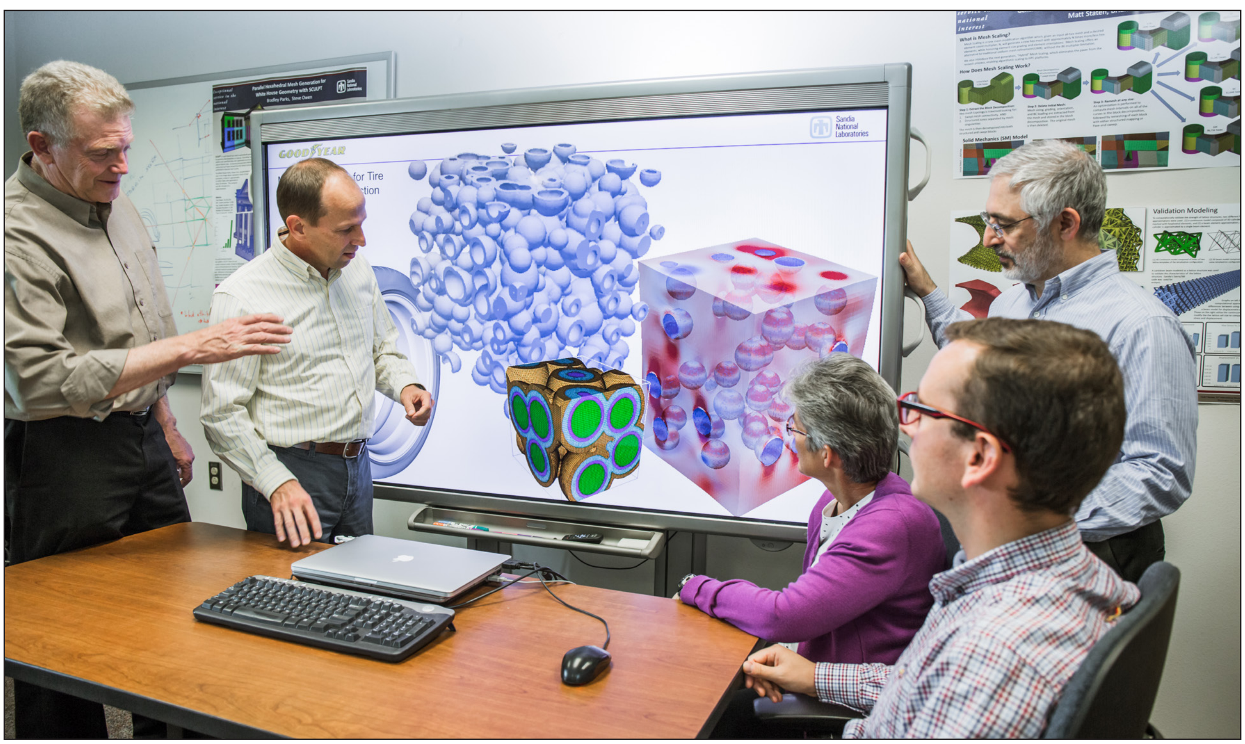
As the code grows more robust through Goodyear's repeated use and modification, the benefits come back to Sandia as well. Enhanced solution algorithms lead to better mechanical simulation for nuclear weapons and other security applications. For instance, the code provides highly accurate curing simulations that test the integrity of polymer seals used in neutron generators, a critical weapon component.

The collaboration between Goodyear and Sandia has been iterative. There have been times when proposed new methods were sidelined until, years later, those same methods turned out to be good solutions. What Goodyear and Sandia learned together is that while some creative technical solutions work well, others should be abandoned in order to keep the process efficient.

"There's always this collaborative effort whenever you get like minds together," Ebbott said. "Something better usually comes out of it. And that happened with us on a regular basis. There was this excitement about being able to utilize modeling and simulation in a way that we hadn't used it before. And this collaboration raised the bar in terms of technology and how we thought about problems at Goodyear. And it helped Sandia come up with ideas about how they could solve the problems on their side."

Ted Blacker, Sandia's manager of Simulation Modeling Sciences, said the partnership has been successful because it is strategic. It has allowed both Goodyear and Sandia to apply the code to real-world problems.

"We focus on strategic technical challenges where advanced technology from both sides can change the future," he said. "Almost without fail, the new capabilities they commission us to develop—for example, to model rotating and twisting tires—helped us with simulations in our national security work."



"There's always this collaborative effort whenever you get like minds together," Ebbott said.

SUPPORT STRUCTURES

A Sandia National Laboratories partnership contributes to the success of the Joint Strike Fighter program

In 1993, the Department of Defense (DoD) established the Joint Strike Fighter (JSF) program initiative to design and develop a fifth-generation fighter jet. The DoD was interested in an aircraft that would combine air-to-air, strike, and ground attack capabilities, for use by multiple branches of the U.S. military and NATO allies.

After an eight-year concept, design, and development competition between several companies, in 2001 the DoD chose the Lockheed F-35 JSF. The most costly and ambitious project in DoD's history, the JSF program will exceed $400 billion over several decades to develop 2,457 F-35s. The F-35 will eventually replace legacy aircraft currently in Air Force, Navy, Marine Corps, and allied military inventories.

For the program to be successful, however, the complexities of international manufacturing and logistics support needed to be sustainable for the U.S. and partners, including Australia, Canada, Denmark, Italy, Netherlands, Norway, Turkey, and the U.K. Complex supply chains across hundreds of facilities around the globe would supply thousands of parts on an ongoing basis. To save time and money, all of these logistics elements needed to smoothly mesh within a comprehensive management solution.

In 2000, Lockheed was in the process of bidding for the JSF contract. As a key requirement for the contract, the JSF needed an international sustainment and logistics component. Lockheed partnered with Sandia National Laboratories (Sandia) to develop its JSF logistics and sustainment program. Through Lockheed's Shared Vision program under Cooperative Research and Development Agreements (CRADAs), Sandia and Lockheed successfully developed the Support Enterprise Model (SEM), a discrete event simulation tool used to model and simulate operation and support activities in a sustainment environment.

Sandia's Bruce Thompson partnered with Lockheed's Devon Smith to lead the Sandia/Lockheed team that developed the SEM tool. According to Thompson, SEM allowed analysts to define an operational/support environment and determine the most efficient solution scenarios even while responding to changes in the support system, procedures, and business objectives. It also tracked aircraft reliability and maintenance options. Mr. Thompson said, "The SEM CRADA gave Sandia the opportunity to use and build upon its expertise in simulation and optimization. We're continuing to use the capabilities developed under the CRADA to benefit the DoD, Sandia's logistics operations, and the DOE/NNSA weapons sustainment enterprise."

In addition to enterprise-scale simulation capabilities, SEM includes a global optimization capability for support resources (e.g., spare parts inventory,

F-35

personnel, and support equipment). This flexible capability works with the SEM simulation to identify, at each location in the global sustainment system, the optimal combination of support resources required to meet specified performance objectives at the lowest cost. Alternatively, the optimization can determine how best to use a given support resource budget to maximize performance.

Bruce Thompson

According to Sandia, SEM is a discrete event simulation tool designed to model and simulate operation and support activities of a worldwide sustainment system. The general objective of SEM is to help characterize the sustainment system performance including supply, repair, and manufacturing activities over the entire life of the enterprise. To accomplish this objective, the user defines and executes SEM simulations to generate statistical results characterizing the enterprise operations using different notional support and sustainment options. Results of those simulations are analyzed to make recommendations for best-case logistics system configurations that support required mission capabilities at the lowest possible cost. SEM is applicable in industries as diverse as defense, energy, aviation, and healthcare, enabling:

- Integrated modeling of supply chain and repair chain activities for a worldwide support system
- Logistics modeling, analysis, optimization, and decision support of global operations
- Calculation of system and support structure performance and cost metrics while accounting for uncertainty
- Spares inventory and resource optimization on a global scale

The remarkable modeling and simulation capability of SEM has proven critical in the design of the JSF logistics support systems. It has led to billions of dollars in savings, by responding to changes and achieving performance metrics at the lowest cost, a capability critical to successful execution of the JSF initiative.

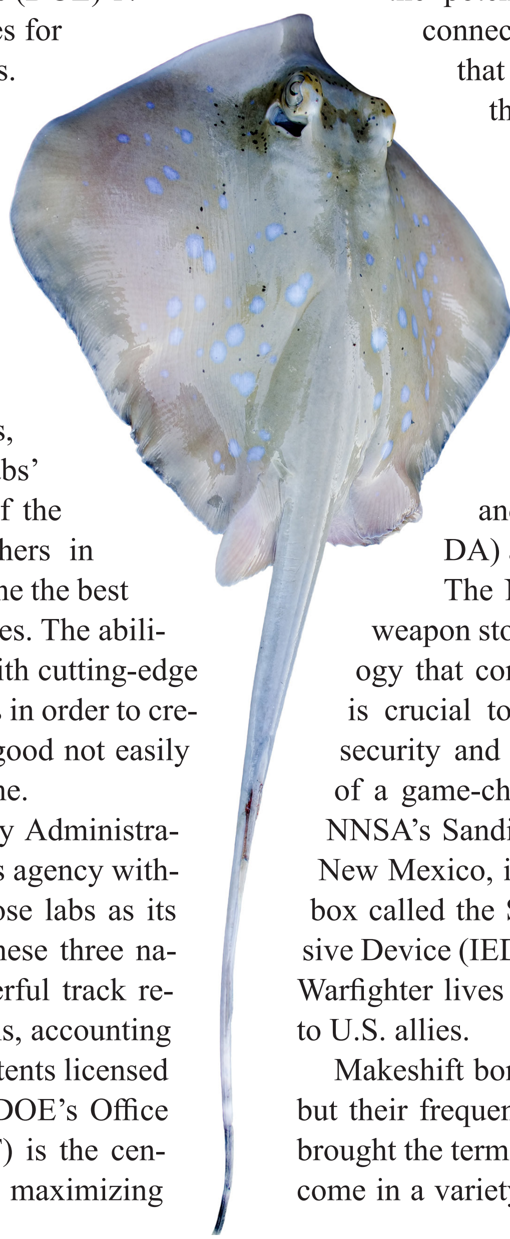
Neither government nor private sector enterprises can afford the risks of untested decisions on the battlefield, in the supply chain, on the factory floor, or even in customer relationships. Management enterprises must understand, up front, the impacts, risks, and robustness of critical operational decisions. SEM provides the ability to test drive new enterprise strategies, policies, practices, and application logic before committing to their execution. Once in place, SEM provides the ongoing support necessary to maintain the enterprise at its highest functional level, at the most economical cost.

Thanks to Sandia and the empowering CRADA, the SEM tool was used by Lockheed Martin Aero, the JSF Program Office, and the JSF International Partners (U.K., Canada, Netherlands, Norway, Italy, Australia, and Turkey) to help design and optimize a global JSF sustainment system. In fact, SEM was so critical to Lockheed Martin's plans that they continue to use it as JSF aircraft are deployed. SEM can be used both as a design tool, which can demonstrate a proposed design's sustainment solutions and provide acceptable operational performance with significant reductions in costs, as well as an operations tool with autonomic logistics functionality that can sense and respond to changes in JSF fleet operations. In addition, two other Lockheed Martin companies have started to use SEM to support multi-billion dollar Performance-Based Logistics programs and to help win additional programs.

SEM also attracted the attention of Lockheed Martin's new Net-Centric Integration Center and was the first Sandia-Lockheed Martin tool deployed in this showcase facility. Sandia continues to use capabilities developed under the SEM CRADA for Department of Defense applications and for modeling and simulation to support the nation's Nuclear Weapons Enterprise.

EXPLOSIVE RESULTS

A licensed technology created by Sandia National Laboratories disables IEDs and saves Warfighter lives


Shutterstock / pistolseven

The Department of Energy's (DOE) 17 national labs are goldmines for innovative technologies. Inventions from these labs are licensed at a rate nearly nine times higher than the global average for research labs. The applied research they engage in is part of a unique management and operating model that allows the DOE to define precise technological needs, while providing the research labs' scientists—composed of some of the most talented scientific researchers in the world—the liberty to determine the best paths to achieve those technologies. The ability for these labs to experiment with cutting-edge tools and seek inventive solutions in order to create new innovations is a public good not easily fulfilled by the private sector alone.

The National Nuclear Security Administration (NNSA), a semi-autonomous agency within the DOE, utilizes three of those labs as its physics and engineering arm. These three national security labs have a powerful track record for technological innovations, accounting for more than half of the DOE patents licensed to commercial companies. The DOE's Office of Technology Transitions (OTT) is the central hub for technology transfer, maximizing the potential of national lab inventions by connecting them with commercial entities that can help develop and manufacture the technologies. NNSA's Office of Strategic Partnership Programs collaborates with OTT to tackle this work through several strategies including workforce programs, policymaking, training scientists to understand entrepreneurial markets, and identifying funding opportunities through programs that results in Cooperative Research and Development Agreements (CRADA) and licensing agreements.

The NNSA is highly focused on nuclear weapon stockpile maintenance, but the technology that comes from the NNSA's national labs is crucial to the agency's goals toward global security and aiding foreign allies. One example of a game-changing technology, born out of the NNSA's Sandia National Laboratories (Sandia) in New Mexico, is a powerful tool the size of a shoebox called the Stingray. It is an Improvised Explosive Device (IED) detonator that has saved American Warfighter lives overseas and become indispensable to U.S. allies.

Makeshift bombs have been around for centuries, but their frequent use in 2003, during the Iraq War, brought the term IED into the common lexicon. IEDs come in a variety of forms, used by insurgents, vandals and terrorists. Their diverse, improvised nature and their ability to lie hidden on roadsides and in propane tanks and packages is exactly what has made them difficult to address. And so, even well into the conflicts in Iraq and Afghanistan, the technology to disarm these crude explosives remained insufficient and outdated.

In 2006, engineers at Sandia National Laboratories began to develop solutions to the IED technology gap. The idea was to create something that could quickly disable IEDs without injuring people or causing excessive damage to the surrounding area. Sandians Steve Todd and Juan Carlos Jakaboski and contractor Chance Hughs worked with lab engineers to design and develop a fluid-blade disablement tool eventually called the Stingray. In 2010, Sandia licensed the technology to a company called TEAM Technologies, facilitating the production and manufacture of the innovation.

> The Stingray's introduction to the world led to an Excellence in Technology Transfer Award and was listed as a top invention in TIME magazine for 2010. Within nine months of the technology transfer process, TEAM Technologies sent 5,000 of the portable, durable devices to military personnel in Afghanistan and Iraq.

"The Stingray is an energetic tool," said Bob Sachs, CEO of TEAM Technologies. "It uses water as a source to cut through materials. Water is actually a very hard substance—that's why water-jet cutting tools are used in manufacturing. It can be a very effective tool for cutting through objects."

Water has long been used in the industrial world to cut marble and other materials, and that same concept applies to the Stingray. The clear, plastic handheld device has two functions: the water blade and the water slug. The water blade is activated when the Stingray detonates. The resulting explosion sends shockwaves through the water. The force of that explosion, which can result in velocities three times the speed of sound, turns the water into the shape of a blade that can cut precisely through steel and other tough materials. The second capability—the slug—creates a more generalized explosion from the back of the device that allows the force of the water to destroy multiple components of the IED.

The choice to use one function over the other depends on the situation. If it is clear where the wires on an IED are, the water blade can cut through that part of the bomb without damaging other aspects, making it easier to analyze the bomb.

"For instance, in places where we're fighting wars in the Middle East, a lot of IEDs are placed in pressure cookers and five-gallon propane tanks," Sachs said. "Once Warfighters find the bomb, they're able to use this device to bust through it—without the bomb going off. They're then able to do forensics on the bomb to find out what it was made of."

To create these blade-like water configurations for either the blade or the slug, the Stingray uses shaped-charge technology, which is what makes the water a specific shape when exploded—unlike a traditional bomb disruptor that releases energy in a generalized manner of equal distribution. This particular characteristic of the technology is also how it gets its name: It explodes in the shape of what looks like the sharp, venomous barb of a stingray.

Even with all its enormous potential, as developed by Sandia, the Stingray was a prototype with nowhere to go. That changed when it was introduced to military trainees at Sandia, who found the technology highly useful and potentially revolutionary. The NNSA tech transfer program worked to find a market for it. When TEAM Technologies heard about the Stingray, it applied for, and received, the license.

The Stingray's introduction to the world led to an Excellence in Technology Transfer Award from the Federal Laboratory Consortium, and was listed as a top invention in TIME magazine for 2010. TEAM Technologies was able to begin mass producing the Stingray in 2011. Within nine months of the technology transfer process, they sent 5,000 of the portable, durable devices to military personnel in Afghanistan and Iraq.

The benefits of the Stingray have been incalcu-

Photo by Randy Montoya

Airman 1st Class Patrick Connolly of Dayton, Ohio, in a training exercise, demonstrates the placement of a Stingray Disruptor, licensed by TEAM Technologies from Sandia National Laboratories. The Stingray's reliability and portability have made it a perfect technology to share with foreign allies in inhospitable environments overseas.

lable, not least because it has saved so many lives. Its reliability and portability have made it a perfect technology to share with foreign allies in inhospitable environments overseas.

"Sandia has now trained thousands of explosive bomb techs on the Stingray Disruptor," said Sandia engineer Robert Todd Miner. "And it is being used in warzones by both our military and our allies all over the world—saving limbs and lives."

The U.S. Department of Defense has also utilized it for homeland security purposes related to terrorism within national borders.

"We do a lot of work across the board in service to defense—it isn't just about nuclear weapons," said Mary Monson, senior manager of Sandia's Technology Partnerships and Business Development. "The technology we develop in the labs here shows great promise for military and homeland security applications. These inventions become invaluable tools to our allies. Something as small as a shoebox can provide important fortification for our overall national—and international—security."

NNSA

National Nuclear Security Administration