PHYSICAL SCIENCES

VISTAS

PERSPECTIVES ON EXCELLENCE IN NUCLEAR SECURITY | ISSUE 4 2021

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Los Alamos
NATIONAL LABORATORY

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Inclusivity tip

To help scientists develop a more complete understanding of damage that weakens materials in nuclear reactors, a new capability is being installed at the Ion Beam Materials Lab (IBML). When finished, it will allow researchers to watch atoms one at a time, using positrons to detect damage literally as it is being created by ion irradiation. The capability will be the first of its kind in the world, offering a unique way to characterize the propagation of physical damage in multiple materials in situ. Here, visiting Bowling Green State University postdoctoral researcher Adric Jones (Materials Science in Radiation and Dynamics Extremes, MST-8) sets up a new target chamber in the IBML.

Physical Sciences Directorate

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On the cover: In this photo illustration, Randy Edwards, a 34-year veteran of the Sigma Electrochemistry and Corrosion Team, prepares a vacuum chamber for gold plating in the renovated finishing lab.

Photos in this issue were taken in accordance with COVID protocols at the time.

FROM TONI'S DESK

Toni Taylor, Associate Laboratory Director for Physical Sciences

In this issue of *Physical Sciences Vistas* we highlight examples of "excellence in nuclear security."

The Lab's nuclear security mission spans a range of initiatives in support of stockpile stewardship, nonproliferation, and global security. The Physical Sciences Directorate plays a key role in aiding those missions through our materials, nuclear physics, and accelerator science expertise and capabilities.

In this issue, highlights of our outstanding work supporting the Laboratory's nuclear security enterprise include the following.

- The complete refurbishment of Sigma's surface finishing lab. Pride in the lab's revitalized condition on the part of the operations and R&D staff responsible for this complex operation is well justified.
- Development of advanced materials and processes enabling next-generation weapons designs, much of which has been facilitated by projects supported by the Laboratory Directed Research and Development Program.
- The use of proton radiography in illuminating elements important to validating high explosive burn models. The experimental series was a collaboration between Los Alamos researchers and staff at Lawrence Livermore and Sandia national laboratories and the United Kingdom's Atomic Weapons Establishment.
- Deployment of a sophisticated remote handling unit to safely transfer highly radioactive materials required to support mission-critical projects.
- The skillful swap of an electrical transformer at the Los Alamos Neutron Science Center (LANSCE). The deliberate operation restored power to the accelerator in less than estimated time.
- A look at George Goff's role in translating fundamental science into applied solutions essential to the Lab's nuclear security mission.

As part of our effort to ensure our continued successful support of the Lab's nuclear security and science, technology, and engineering missions, we have made key strides in maintaining, improving, and enhancing the appearance of our facilities. While this does not happen overnight, I am proud of the progress made to date and am committed to continuing to focus on these areas. Equally as important is providing strong stewardship of our programmatic assets. As you are aware, we have spent the past year developing the necessary infrastructure to stand up an asset management program for our major programmatic assets at LANSCE and Sigma.

At a high level, this effort has worked to identify the elements necessary for us to understand a subset of our critical systems and equipment and develop policies, procedures, and processes that will help us better understand the status of those systems and equipment. The end result is proactive monitoring and maintenance, increased knowledge transfer and ensured program sustainability, and an agile, responsive infrastructure. By formalizing these processes and centralizing the management of the data and materials we will be able to track and trend performance, make informed investment decisions, and continuously learn and improve.

Our pilot will start in June. In the next few months, you will likely hear more about this effort. I am hoping as we implement and learn more, you will share my enthusiasm for the initiative. Efforts like this help us become more effective and efficient and increase focus and efforts on mission execution.

Toni

Commitment to mission galvanizes effort to **modernize Sigma finishing shop**

A robust surface finishing capability is critical to the Lab's nuclear security enterprise. For more than six decades the Sigma Complex has been home to a large, dedicated space for the performance of world-class surface science, supporting mission-essential parts production and manufacturing methods development.

Yet years of use with few updates had left the surface finishing lab in disrepair, challenging the creativity of the Electrochemistry and Corrosion Team, which is tasked with meeting current mission deliverables and preparing for new mission needs.

Now, in an act of careful coordination between R&D and operations staff, the lab has been completely rebuilt and "is back better than ever," said Electrochemistry and Corrosion Team Leader Dan Hooks (Finishing Manufacturing Science, Sigma-2). "It remains the only full-scale finishing facility in the DOE and is now world class by any standard."

Driving this endeavor has been a program need for war reserve component production and space, hydrotest, and other critical research hardware. The renovation is now complete after more than two years. The lab, Hooks said, "is ready to serve anyone at the Laboratory needing research for coating development or corrosion and interface effects and coatings on research hardware or anything else."

Simultaneously delivering for mission success

Faced with often daunting infrastructure challenges, the 50-member construction crew became adept at overcoming unexpected facility conditions. They also successfully weathered procurement delays, materials shortages, and complex COVID-19 work protocols. Their approach—which integrated the efforts of construction maintenance staff with facility operations staff, program management, and industrial hygiene and radiation protection professionals—resulted in the removal of thousands of gallons and pounds of hazardous waste and the lab remade with new utilities and equipment.

"Our craft took great pride in this project as they felt to be part of the Laboratory mission," said Sigma Construction Manager Miguel Duran (Construction Managers Core, CM-CORE), adding that the end result was delivery of a one-of-a-kind electrochemistry lab.

To deliver on mission-critical products, the 25-member Electrochemistry and Corrosion Team adapted to the circumstances. Working seven days a week in rotation, in conditions

The Sigma Electrochemistry and Corrosion Team includes (from left) Dan Hooks, Jamie Stull, Randy Edwards, Courtney Clark, Don Johnson, Allen Gresham, Mary O'Brien, Tim Gorey, and Brad Carpenter.

that sometimes included no heat, light, or running water, team members produced to-specification satellite components, thousands of detonator cables, and other essential components for Lab missions.

"In short, the technical team delivered in imperfect circumstances, and the construction team pulled off an extraordinarily difficult renovation," Hooks said.

New tools for a new age

The Electrochemistry and Corrosion Team performs surface and interface characterization, coatings development, corrosion testing, and processing of highly diverse materials from the nanoscale to production scale. The results of its work range from one-off hardware to routine production of parts and studies into material's aging and lifetime behaviors for research and development, weapons, and space applications.

Team members are already thrilled by the shop's new capabilities, Hooks said. For example, leveraging these new capabilities, the team is developing novel processes to ensure the surfaces of additively manufactured metals meet roughness and corrosion requirements.

The finishing industry "hasn't seen anything" like the surfaces produced through this new technology, Hooks said, yet "the expectation is that the parts can still meet surface specifications. Taking it from the beaker to industrial practice is made possible by the new Sigma electrochemistry and corrosion lab." ■

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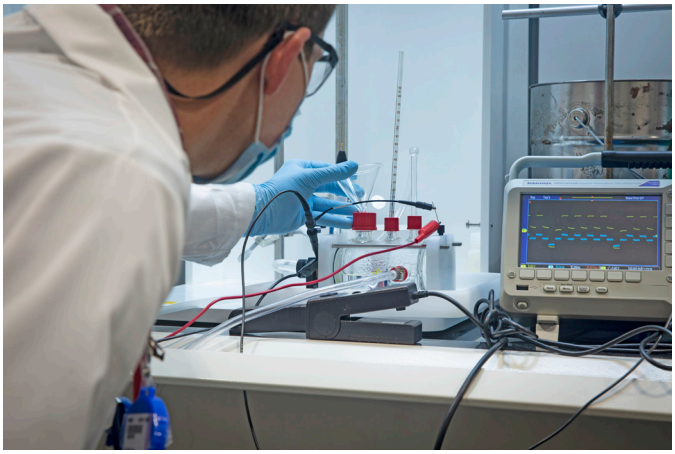
Commitment continued ...

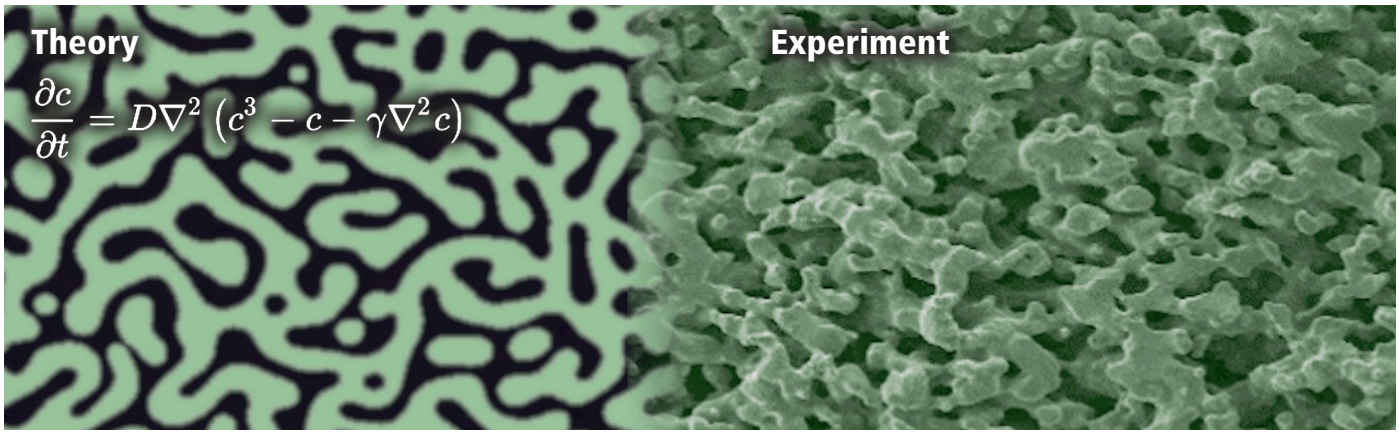


Clockwise from top left: Jamie Stull inspects gold-plated vanadium parts. Randy Edwards prepares for nickel plating by installing new anode. Tim Gorey performs experiments developing pulse-reverse electropolishing to prepare additively manufactured metal surfaces. Allen Gresham racks coupons for chromate coating and subsequent salt-spray quality testing. Don Johnson prepares a vacuum chamber for gold plating.

Get the details

Making the renovation possible were craft workers from Logistics Central Shops (LOG-CS) and Logistics Heavy Equipment Roads and Grounds (LOG-HERG) and field engineers from Engineering Services-Facility Engineering (ES-FE). The Weapons Infrastructure Program funded the Sigma electrochemistry and corrosion lab renovation. **Technical contact:** Dan Hooks

Developing innovative materials technology to advance the state of the nation's stockpile



Left: Theoretical prediction of a porous foam material formed by a spinodal decomposition process. Right: Microscopy image of a silicone foam fabricated by the Advanced Materials and Processes Team in Engineered Materials.

In support of the Lab's national security science mission, a multidisciplinary team of researchers in Engineered Materials (MST-7) is crafting novel materials synthesis and manufacturing technologies to enable novel weapons design and agile modernization of the nation's current and future nuclear stockpile.

In the past three years, MST-7's Advanced Materials and Processes Team has filed eight US patent applications on various materials advances and led several new research endeavors with collaborators across the Laboratory. These range from simple and scalable routes to porous silicone materials with controlled properties, to additively manufactured wicking materials for heat transfer applications, to novel scintillating composites and dissolvable ceramics for metal investment casting in complex architectures.

"As the US continues the transition into the era of 'great-power competition,' it is important for the nuclear security enterprise to rapidly respond to unforeseen threats and technical surprise," said Program Director Jon Rau (Engineering and Technology Maturation, ETM). "The discoveries made in Engineered Materials, specifically within the Advanced Materials and Processes Team, are important pieces of that puzzle. Proactively developing new, easily manufactured materials with tailored properties enables the rapid delivery of new capabilities to the warfighter, while ensuring the viability of the current deterrent."

Much of this work has been facilitated by the team's leadership in Laboratory Directed Research and Development projects—both Exploratory Research and Mission Foundation endeavors. These include projects focused on engineering functionality and structural hierarchy in additively manufactured materials, integrating additive manufacturing and investment casting for complex metal architectures with predictable mechanics, and creating an acoustic-optical transducer.

Capitalizing on the success of these fundamental science projects, the team has adapted these advances toward solving key technical problems for the weapons program at the Lab.

In their research, team members strive to adhere to Da Vinci's principle that "simplicity is the ultimate sophistication," according to Team Leader Matthew Lee (MST-7). "In my view, a simple solution to a complex problem compels the deepest possible understanding," Lee said. "This is especially true for our weapons materials research." For example, a new material or process must not only fulfill an array of technical requirements, but also be manufacturable, reproducible, and possess predictable longevity and compatibility.

To meet that goal, Lee calls on the multidisciplinary expertise of his team, which includes engineers, chemists, physicists, and polymer/materials scientists. "It's incredibly fulfilling to work alongside such creative and passionate people in service to the nation," Lee said. ■

Get the details

Members of the Advanced Materials and Processes Team include Diego Aubert-Vasquez, Kyle Cluff, Matthew Crall, Cordell Delzer, Alexander Gomez, Amanda Graff, Luke Kruse, Matthew Lee, Martin Oltmanns, Cameron Richards, Emily Tew, and Brenden Wiggins (all Engineered Materials, MST-7). Their work supports the Lab's Stockpile Stewardship mission and Materials for the Future science pillar.
Technical contact: Matthew Lee

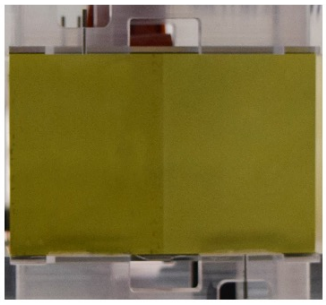
Using pRad to compare high explosive ignition and burn performance

The quad labs experimental series, fielded at the Los Alamos Neutron Science Center's Proton Radiography (pRad) Facility, is designed to study dead zone formation and evolution caused by different booster and donor high explosive materials. The detailed measurements generated in this inter-laboratory project provide important validation data for high explosive burn models.

"Such models are an integral element of the Lab's stockpile stewardship mission," said Kathy Prestridge (X Theoretical Design, XTD-DO) who served as pRad project leader during the series. Los Alamos National Laboratory, Lawrence Livermore National Laboratory, Sandia National Laboratories, and the United Kingdom's Atomic Weapons Establishment participated in the design, simulation, execution, and analysis of the experiments.

pRad captures the density inside the explosive charges during ignition and detonation, and the radiography is time- and space-resolved, so images of detonation fronts, their shapes, their speeds, and the density of explosive products are measured in a pRad movie. The formation, size, and shape of dead zones, when the explosive does not burn as efficiently, can also be seen in the pRad movie, providing information about the detonation that is not available with other diagnostics.

The experiments are in the shape of a rectangular puck of explosives (Figure 1). There are four different experiments in each shot, with two detonators and conventional high explosive boosters on the top and bottom and two different insensitive high explosive acceptors on the left and right. This allows simultaneous comparison of the burn and dead zones for all four acceptor-booster combinations. Figure 2 shows two proton radiographs of the detonations. The size and shape of the dead zones in the EDC 35 explosive were not predicted by calculations. Analysis by explosives scientists will compare the evolution of the dead zones with time and the shape and speed of the detonation waves to those in calculations to improve numerical modeling of explosives in complex configurations. ■



From left: Matt Davis and Jason DeVargas prepare the shot stand for a quad labs experiment. The stand is attached to the lid of the pRad vessel. The assembly is lowered into the vessel after all diagnostic connections are made and armor is placed to prevent fragments from damaging the vessel.

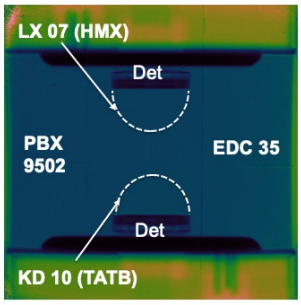


Figure 1. Photo (left) of one of the quad labs experiments just before it is placed in the proton radiography vessel, and static proton radiograph (right) after it is put into the vessel in preparation for firing. Detonators on the top and bottom simultaneously ignite two different boosters (LX 07 and KD 10) that are embedded in the insensitive high explosive blocks (PBX 9502 and EDC 35). The geometry allows study of four different ignition systems simultaneously.

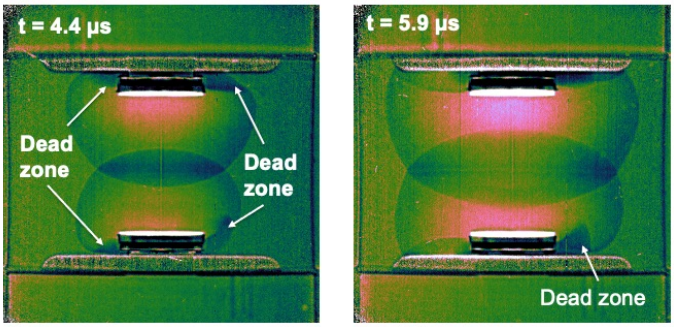


Figure 2. Proton radiographs of the detonation of the experiment shown in Figure 1. Detonation fronts are the large bubble-like structures and dead zones are the dark areas near the detonators.

Get the details

Contributing to LANL's proton radiography capability were Mary Sandstrom, Pam Scott, Jason DeVargas, Matt Davis, Devin Cardon, and Ryan Vliestra (High Explosive Operations, M-3); Frans Trouw, Kathy Prestridge, Carl Wilde, Josh Tybo, Matthew Murray, Jason Allison, Matthew Freeman, Amy Tainter, Levi Neukirch, Julian Lopez, Jason Medina, Wil Meijer, Tamsen Schurman, Dale Tupa, Zhaowen Tang, Fesseha Mariam, Andy Saunders, and Chris Morris (Dynamic Imaging and Radiography, P-1). Los Alamos principal investigators are Christina Scovel (XTD Primary Physics, XTD-PRI); Rosemary Burritt (High Explosives Science and Technology, Q-5); and Eric Anderson (Shock and Detonation Physics, M-9). Atomic Weapons Establishment principal investigators are Sara French, Matthew Maisey, and Paul Willis-Patel. **Funding:** This work was supported by the Engineering and Technology Maturation Program in support of the nuclear weapons program. **Technical contact:** Frans Trouw, acting pRad project leader

Lights, camera, action!

Remote handling unit shines in Lab's harsh environments

With long, jointed arms that end in metal pinchers and a bold yellow and black body perched above a tank-like tread and stout reinforcement legs, the device looks primed for action in a sci-fi movie.

Indeed, the remote handling unit in service at the Los Alamos Neutron Science Center has already played a role in advancing the Lab's scientific capabilities. The device was recently used to safely transfer a cobalt-60 source from a shipping cask into a permanent cask for use with the Scorpius project. Scorpius will be a new radiographic diagnostic used to examine the dynamic behavior of plutonium under weapons-relevant conditions.

Employing the remote handling unit limited worker exposure to the highly radioactive source that is part of the development of the 20-MeV particle accelerator that will generate x-ray images of subcritical implosion experiments for the nuclear weapons program. "This was the first 'hot' job that the equipment was used for," said Accelerator Operations (AOT-OPS) Group Leader Eron Kerstiens.

A multidisciplinary team from organizations across the Laboratory used Safe Conduct of Research principles to develop the work process and controls and the specialized equipment for the transfer. "Several dry runs were completed to hone in on the process, and when the job was finally performed it was executed without issue and with very minimal dose to personnel," Kerstiens said.

The device was originally procured to replace and dismantle radioactive targets that had reached their service lifetime. It replaces obsolete remote handling equipment that was designed for a different purpose. The new equipment incorporates ease of setup, low maintenance, mobility, and strength and lifting capabilities that the old equipment did not have.

This month the device will be used to cut the highly radioactive proton beam window off of the Isotope Production Facility's window insert mechanism in order to analyze and reduce in size the rest of the insert mechanism for disposal. In March, the device will be used to swap LANSCE's Target Moderator Reflector System Mark III with the Mark IV, which has been enhanced to provide some flight paths with higher energy neutrons for use in nuclear physics experiments. The Mark III is expected to have a radiation dose of about 15,000 R/hr so using the remote handling unit is a necessary ALARA (as low as reasonably achievable) measure, reducing radiation exposure to personnel in a variety of activities.

The remote handling unit is shown here being used in a practice run in preparation for cutting apart a beam window assembly from the Isotope Production Facility.

The unit is a one-of-a-kind capability for the Laboratory, according to Kerstiens. At a distance and shielded from the used target's radiation, an operator wields a mechanical arm connected to a computer to remotely manipulate the arms of the machine, thus making it essentially a surrogate for human handling of hazardous materials or materials in extreme environments. Similar types of manipulators have been used for Titanic exploration missions, for example.

The device includes "a fully haptic manipulator system," Kerstiens said, meaning, "when the manipulator squeezes, lifts, or bumps something, the operator feels it." This also applies to the weight lifted by the mechanical arms, which is adjustable. In lifting a 200-pound object, the operator can set the system so that it feels like just 2 pounds. The new manipulator is hydraulic, capable of lifting up to 500 pounds per arm; an improvement over the previous system, which could lift only 40.

Multiple possibilities exist for the unit's use in the Laboratory's diverse extreme environments. "This could possibly include electrical, oxygen-deficient environments, and explosive environments," Kerstiens said. ■

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Get the details

Key to the cobalt-60 transfer were staff in Accelerator Operations (AOT-OPS); Applied Engineering (AOT-AE); Applied and Fundamental Physics (P-2); Advanced Sources Detector Project (ASD); and Radiation Protection Field Support (RP-FS). **Funding**: Weapons Infrastructure funded procurement of the unit. **Technical contact:** Eron Kerstiens

Remote handling continued ...

The new manipulator is hydraulic, capable of lifting up to 500 pounds per arm; an improvement over the previous system, which could lift only 40. The manipulators are the Predator model provided by Kraft Telerobotics and are mounted to a Brokk 200 electrohydraulic mobile platform.

Members from the cobalt-60 source transfer team look on as Esteban Garcia operates a manipulator to remove a thumb tack-sized cobalt-60 source from one cask and place it in another cask.

The multi-organization cobalt-60 source transfer team poses for a photo after successfully using the remote handling equipment to transfer the radioactive source between two casks. From left: Sean Hollander, Esteban Garcia, Brian Adkison, Kevin Andrews, Joseph Le May, Seth Dubose, Michael Duran, Jordon Marquis, Ryan Smeltzer, Jen Bohon, and Benjamin Tobias.

Teams amp up creativity to safely and efficiently swap transformer

Deliberate actions restore power to accelerator in less than estimated time

For almost a half century, the Los Alamos Neutron Science Center (LANSCE) has provided the scientific underpinnings in nuclear physics and material science needed to ensure the safety and surety of the nuclear stockpile into the future. Driving that research is one of the nation's most powerful proton linear accelerators, which provides beam current, simultaneously, to five major facilities with unique capabilities.

In late September the transformer delivering electrical power to the accelerator's injector region suffered an irreparable failure. Without that power, the accelerator was out of commission—and research at the facility came to a halt.

Unfortunately, no "like-for-like" replacement for the decades-old transformer existed on site.

Committed to getting the accelerator back on line and the beam run cycle resumed as quickly as possible, members of Utilities and Infrastructure (UI) and LANSCE's engineering, maintenance, and operations teams came together to research and find a solution.

"This effort highlights the original thinking and dedication to safety of those who support the operation of LANSCE," said Facility Operations Director Gary Hagermann (LANSCE-FO).

Within days, a replacement transformer was identified and its suitability and condition tested by UI. Assured that the transformer met requirements, the team coordinated its plan with all stakeholders as the transformer swap would affect operations up and down the LANSCE mesa. UI removed the old transformer and installed the newer one in two days, using a complex switching procedure that maintained most of the power to areas not affected, while controlling hazardous energy with lockout/tagout practices. After testing by UI to confirm the transformer met the needs of the accelerator, LANSCE was ready for restart. Replacement of the transformer was completed a week ahead of the initial schedule and without incident.

In a slow and deliberate manner, to ensure no further damage would occur, Accelerator Operations and Technology staff started up accelerator systems and began tuning the beam. "These actions resulted in less down time than expected and a successful recovery," Hagermann said.

LANSCE returned to full beam operations by mid-October.

Prior to this event, LANSCE management was evaluating how to make the power distribution system both more robust and more reliable into the future. According to LANSCE User Facility Director Mike Furlanetto (Physical Sciences, ALDPS), those efforts will continue in order to minimize the chances of another such upset in the future. "LANSCE data will be needed for decades to come and we must modernize our infrastructure to support that need," he said. ■

The Lab's rigging crew used a mobile crane and flatbed truck to transport and position the transformer.

continued on next page ▶

Get the details

Participants: Members of Utilities and Infrastructure (UI); LANSCE Facility Operations (LANSCE-FO); and Accelerator Operations and Technology (AOT) divisions. **Funding:** Safety, Infrastructure, and Operations (NA-50) and Infrastructure Support. **Technical contact:** Gary Hagermann

Teams amp up continued ...

From left: Lineman foreman Adam Montoya and apprentice Reynaldo Atencio install the transformer.

Inclusivity tip

Take a minute to update your email signature to include your personal pronouns. This is a simple and easy way to make everyone feel comfortable and included. For the template and updates, visit the Lab's template downloads page.

MEET GEORGE GOFF

Deputy group leader, Materials Synthesis and Integrated Devices, MPA-11

As a deputy group leader and the lead liaison for his group's weapons science and actinide separations efforts, George Goff works with a lot of people across the Lab. And that suits him fine. "I enjoy the people the most," he said. "It is really exciting to come to work and talk to experts in different fields."

In support of the Lab's nuclear security mission, Goff and his collaborators—which include members of Materials Physics and Applications, Actinide Materials Processing and Power, Chemistry, Theoretical, and Engineering divisions—are "taking fundamental science and translating that into real-world applications," he said. These applications range from critical materials recovery to plutonium manufacturing and nuclear fuel cycles.

In particular, Goff leads a multidisciplinary team in modernizing chemical processing capabilities required for the Lab to meet its 30 pits-per-year production mission. The Advanced Separations Technologies Project increases the efficiency of work processes, thereby shrinking their ultimate "footprint" while still meeting the increased throughput requirements. These improvements also mean workers will receive lower doses of radiation due to processes taking less time.

"Whether we agree with nuclear weapons or not, we have produced nuclear materials and waste associated with those production processes, and we have a responsibility to keep our stockpile safe and secure in the most efficient way possible for our workers," Goff said. "LANL plays a key role in that in the US."

Despite the challenges inherent in such a high-stakes project, Goff's pride in his team's accomplishments is apparent. "It's not often that we can have such a tremendous impact on Lab missions," he said. "It's gratifying that we're trusted to execute this mission and that our sponsors have confidence in what we're developing." ■

Technology providing a novel approach to electric grid security has been recognized with a 2021 R&D 100 Award. Developed by Los Alamos researchers and collaborators, "Quantum ensured defense for the smart electric grid" uses single light particles (photons) to create cryptographic "keys" that "lock" control signals into secret codes to protect the electric grid from third-party infiltration. Here, Claira Safi (Space Data Science and Systems, ISR-3) and Raymond Newell (MPA-Quantum, MPA-Q) verify system performance prior to a field test with partners at Oak Ridge National Laboratory and EPB, an electric power utility in Tennessee.

Associate Laboratory Director for Physical Sciences: Antoinette J. Taylor

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