nuclear weapons journal

Issue 1 2009

Los Alamos

Glenn Mara, the Principal Associate Director for Weapons Programs, announced his decision to retire from Los Alamos National Laboratory effective June 1, 2009. As Principal Associate Director for the past 3 years, Glenn successfully guided the Laboratory's weapons programs through some unique challenges and opportunities and leaves the programs in good standing with DoD customers and NNSA. His boundless energy and enthusiasm in support of national security programs and the people who make them happen are hallmarks of his long and productive career with Los Alamos and Lawrence Livermore national laboratories.

Under Glenn's leadership and management of the weapons programs, Los Alamos National Laboratory built and delivered 10 W88 pits to the nuclear stockpile, restoring the nation's ability to produce war-reserve-quality pits after the Rocky Flats Plant closed in 1989. In addition, the Laboratory delivered the first production unit for the W76-1 Mk4A Life Extension Program, culminating 10 years of work to design, develop, produce, and certify a refurbished warhead without an underground nuclear test. His tenure has been marked by a series of scientific and engineering firsts, including installation and operation of the 1.105 petaFLOPS Roadrunner supercomputer and four pulses from the second axis of the DARHT Facility. In addition, Glenn chaired the NNSA-wide Weapons Integration Committee and personally led the initiative for employee and community involvement in public hearings on NNSA's Complex Transformation Supplemental Preliminary Environmental Impact Statement preferred alternative.

We dedicate this issue of the *Journal* to Glenn and wish him the best in his retirement.

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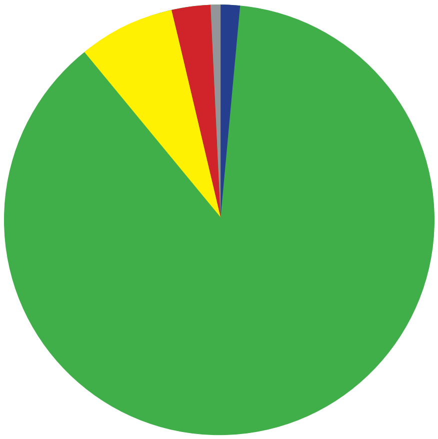
About the cover: Rendering of Manhattan Project buildings around Ashley Pond in Los Alamos. The actual photo of the buildings appears on page 27 in the article titled "Environmental Cleanup."

Weapons Programs Performance Snapshot

With this issue, we introduce a new feature, the Weapons Programs Performance Snapshot. This feature is designed to give our external customers data on how the weapons programs are performing in three critical areas: meeting Level 1 and Level 2 programmatic milestones, as well as meeting safety and security metrics.

Weapons Programs Level 1 and Level 2 Milestones (139)

October 2008 through December 2008 (as of January 30, 2009)



▨ no status provided __1
🟥 generally unachievable as stated __4
🟨 some issues exist __10
🟩 generally on track, no substantive problems _122
🟦 complete __2

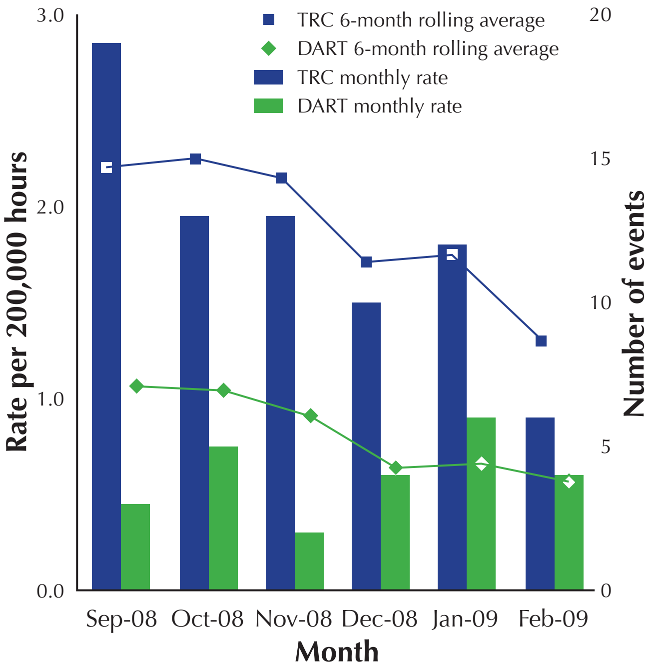
Level 1 (L1) milestones—very substantive, multiyear, supposed to involve many, if not all, sites

Level 2 (L2) milestones—support achievement of L1 goals, annual

Milestones are reported to NNSA program management on a quarterly basis. Progress on milestones is entered into the Milestone Reporting Tool (MRT).

Safety Trends Continue to Improve

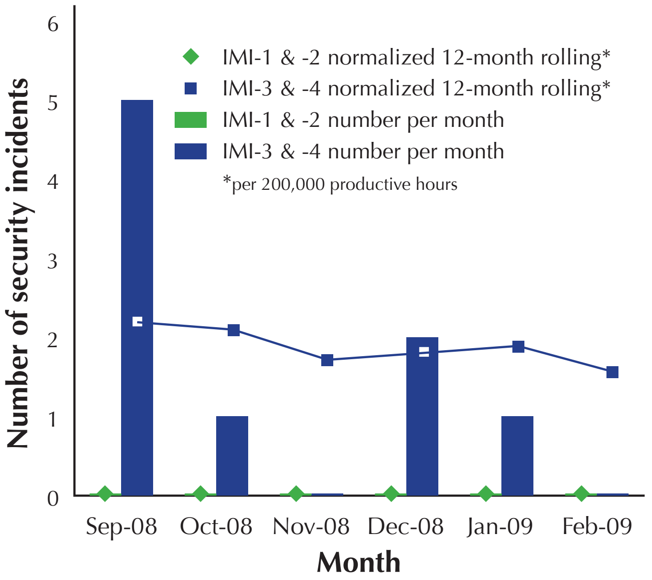
September 2008 through February 2009



- TRC—total reportable cases = those that result in any of the following: death, days away from work, restricted work or transfer to another job, or medical treatment beyond first aid or loss of consciousness
- DART = days away from work, restricted work activity, or transfer to another job as a result of safety incidents

Security Trends Continue to Improve

September 2008 through February 2009



Incidents of security concern (IOSCs) are categorized based on DOE's IMI table (*right*). The IMI roughly reflects an assessment of an incident's potential to cause serious damage to national, DOE, or LANL security operations, resources, or workers, or degrade or place at risk safeguards and security interests or operations.

Categories of Incidents of Security Concern

(DOE M 470.4-1, Section N)

IMI-1	Actions, inactions, or events that pose the most serious threats to national security interests and/or critical DOE assets, create serious security situations, or could result in deaths in the workforce or general public.
IMI-2	Actions, inactions, or events that pose threats to national security interests and/or critical DOE assets or that potentially create dangerous situations.
IMI-3	Actions, inactions, or events that pose threats to DOE security interests or that potentially degrade the overall effectiveness of DOE's safeguards and security protection programs.
IMI-4	Actions, inactions, or events that could pose threats to DOE by adversely impacting the ability of organizations to protect DOE safeguards and security interests.

Point of View

NNSA Announces the Preferred Alternative

Joseph Martz, Staff Member
Principal Associate Directorate for Weapons Programs
Los Alamos National Laboratory

On December 16, 2008, NNSA Administrator Thomas D'Agostino signed two records of decision to begin implementing plans to downsize and transform the nuclear weapons complex. "We can now start moving forward on much-needed consolidation and reductions throughout our national security enterprise, shifting to more cost-effective operations that will save the taxpayer money," said D'Agostino from Washington, DC. "This will improve the safety and security of the infrastructure that maintains US nuclear weapons, helps prevent the spread of nuclear weapons and material, and responds to potential nuclear terrorism or other emergencies."

D'Agostino continued, "I am convinced that our plan is the best path, and that the need for change is urgent. We must act now to adapt for the future and stop pouring money into an old, cold war weapons complex that is too big and too expensive."

The records of decision define a plan called Complex Transformation that will consolidate missions and facilities within the existing NNSA sites, known as distributed centers of excellence. Eight major facilities collaborate to keep the nation's stockpile of nuclear weapons safe and reliable without underground testing. These eight facilities are: Lawrence Livermore National Laboratory, Sandia National Laboratories in New Mexico and California, Pantex Plant, Savannah River Site, Kansas City Plant, Y-12 National Security Complex, Nevada Test Site, and Los Alamos National Laboratory. Although the records of decision outline the future direction of the nuclear weapons complex, they do not commit to a timeline, specific budget, or size or capacity for any one facility.

NNSA developed a range of reasonable programmatic alternatives for the nuclear weapons complex that could reduce its size, reduce the number of sites with Category I/II special nuclear material, eliminate redundant activities, and improve the responsiveness of the complex. The Preferred Alternative in the records of decision is NNSA's choice, and it specifies that LANL will retain three centers of excellence: nuclear design and engineering, supercomputing, and plutonium. This latter role, although critical, is often misunderstood and is the focus of the remainder of this discussion.

All plutonium operations from throughout NNSA will be consolidated at LANL. As a component of this, LANL will provide a plutonium research, development, and manufacturing capability within Technical Area (TA) 55. NNSA has not recommended an updated capacity for pit production, pending a new Nuclear Posture Review to be conducted in 2009 or later. The current production capacity at TA-55 is 20 pits/year.

The Preferred Alternative specifies that NNSA will continue to design the Chemistry and Metallurgy Research Replacement (CMRR) Facility. The CMRR will allow NNSA to better support national security missions that involve plutonium and other actinides, e.g., nuclear fuel R&D, emergency response, and nuclear counterterrorism.

The following excerpts from interviews with three LANL experts indicate how some scientists feel about Complex Transformation and the role that LANL will play in the Preferred Alternative.

Talks With the Experts

Robert Putnam, Director of Pit Manufacturing, cut right to the heart of the matter, "The primary drivers for NNSA in developing its plans for complex transformation are budgetary, scientific and technical, and political. The DOE/NNSA budget cannot afford the current nuclear weapons complex footprint. The reduced stockpile that is the result of the Moscow Treaty and future strategic trends does not require it. NNSA can save 100 million dollars annually in expenditures, including reductions in environmental and security costs."

NNSA's current plans for Complex Transformation stem from the now-defunct Complex 2030 study. As Putnam put it, "NNSA looked at what was reasonable—what made sense—and determined that Complex 2030 specifications weren't feasible either economically or in terms of forcibly relocating personnel. (Complex 2030 called for a return to earlier plans to relocate the entire nuclear weapons complex at one isolated facility that could be easily secured.) NNSA took the recommendations of Complex 2030 and studied them—on a business basis, a technology basis, and a risk basis—and then developed its Complex Transformation plans."

> **"We can now start moving forward on much-needed consolidation and reductions throughout our national security enterprise, shifting to more cost-effective operations that will save the taxpayer money," said D'Agostino**

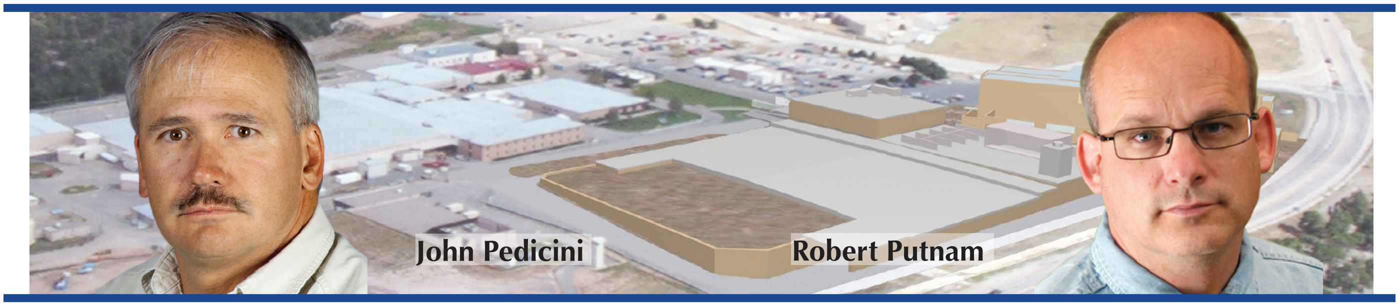
John Pedicini, a weapons design team leader in the Applied Physics Division, concurs that the current plan is more developed and takes a longer-term view than previous transformation plans. "The earlier plans were reactionary—developed from the still-prevalent cold war perspective. This effort has the advantage of being an attempt to anticipate the future rather than react to past and current situations. This initiative has more of a 'looking to the future' aspect to it."

Pedicini noted, "…the fixed costs (e.g., LANL's security perimeter) are eating us alive. The current initiative is forced by necessity. We must get our fixed costs under control by consolidating operations within a common security perimeter."

Pedicini is adamant that we must not lose our focus on basic science and first-principles research at Los Alamos. "With consolidation, there is a risk that LANL will lose its R&D mission—that because LANL is the pit production facility, the high-tech goes to California. The key for LANL is to maintain its role as a national security science laboratory—to continue multidisciplinary research in a wide variety of fields: large-scale simulation and modeling, large-scale experiments, physics research, esoteric physics research, materials science research, and to maintain a strong engineering base. Lacking any of these basic capabilities will reduce LANL's usefulness to the nation. We need to make the case for the pressing need to continue to develop the experimental basis required to refine our models."

Dave Clark, Director of the Laboratory's Seaborg Institute for Transactinium Science, echoed these sentiments. "One focus of current research at the Seaborg Institute is solving legacy waste issues. Part of solving those issues is modernizing the Lab's infrastructure and processes to produce less pollution—smaller volumes of effluent and effluent with lower levels of contamination. We have the most advanced waste treatment facilities in the nation. And we are working toward zero toxicity in our effluent and finally toward a day when the Laboratory has zero effluent."

Clark continued, "If we can finish construction of the CMRR, we will have a state-of-the-art nuclear facility: air handling, water treatment, and radionuclide storage and handling. NNSA's Preferred Alternative will help with this. That plan makes this facility's completion a priority. This new facility will not only help us reach our goals of reducing effluent toxicity and output, but its laboratories and facilities will greatly assist us in our research to advance the technology related to environmental cleanup."



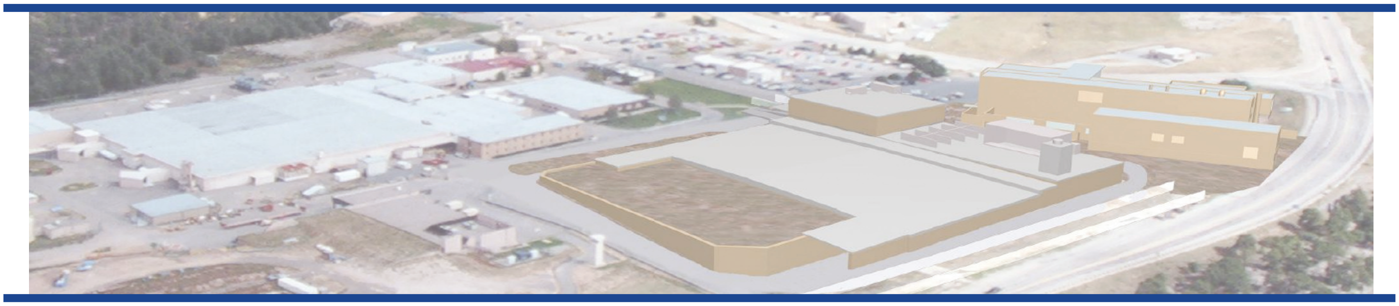
"There is a misconception that CMRR will be used for pit manufacturing. That is not the case. Those manufacturing facilities already exist. CMRR will collocate actinide research facilities with existing manufacturing facilities to consolidate the security perimeter necessary to protect the sensitive materials necessary for both efforts. We will have better protected assets, smaller facilities, and a smaller footprint."

Putnam is also optimistic about the effect that NNSA's transformation plans will have on ongoing plutonium research, development, and manufacturing at TA-55. "Once NNSA's Complex Transformation plans begin to come to fruition and improved facilities become available, we can increase our current pace of process improvements and process upgrades. Right now, to produce a pit, we must purify several times more plutonium than we actually use in the pit. By reducing the amount of plutonium used at the front end of the manufacturing process, we can reduce the liquid and solid waste streams that result from the entire manufacturing effort."

The new and improved facilities, Putnam continued, will allow LANL to serve the nation as a national laboratory. "The US was the only recognized nuclear power not capable of building and certifying a pit for its stockpile for more than 19 years. The key to a reduced stockpile is how credible the deterrence is in what remains. In the past, we have had to maintain a large inventory in order to have a credible deterrent."

"The deterrent is credible only if you can draw from the larger stockpile of warheads. In this mode, the manufacturing capability is the deterrent—we depend on an established manufacturing arm rather than an

The Radiological Laboratory/Utility/Office Building will house office and light laboratory space and is the first phase of the CMRR Project. LANL will conduct very small-scale plutonium analysis, limiting the total amount of plutonium in the building to less than 8.4 grams at any one time.



on-the-shelf warhead for deterrence. This is where NNSA plans to go. Not to build 50 to 80 pits/year, but to build and maintain the *capability* to do so."

Pedicini also sees the benefit to the nation in maintaining capabilities that are not strictly limited to the nuclear weapons program. "LANL has a history of answering the nation's call in the area of energy research. We can really contribute to cooperative ventures with reactor firms—contribute to design and rebuild our expertise in civilian nuclear power. Cooperative research and development agreements, or CRADAs, with industry and business can really expand our expertise beyond weapons research. The diversity of our research and capabilities only strengthens our justification as a national lab in service to the nation."

Pedicini also sees LANL providing the nation with valuable capabilities in the rapidly expanding area of threat reduction. "Our expertise and nuclear weapons skills are a key for our capabilities in this area. The intelligence community views us as a resource. They bring their information to us for scientific evaluation. We need active designers, engineers, and basic research scientists to be an effective resource."

Clark elaborates on this point. "This institution has always had a great desire to delve deeper into other energy research such as advanced nuclear systems—we are the only place in the nation that can work with transuranic nuclear fuels systems. Other examples are an automated, compact nuclear reactor for the probe on the Jupiter Icy Moons Orbiter and radioisotope thermoelectric generators for NASA.

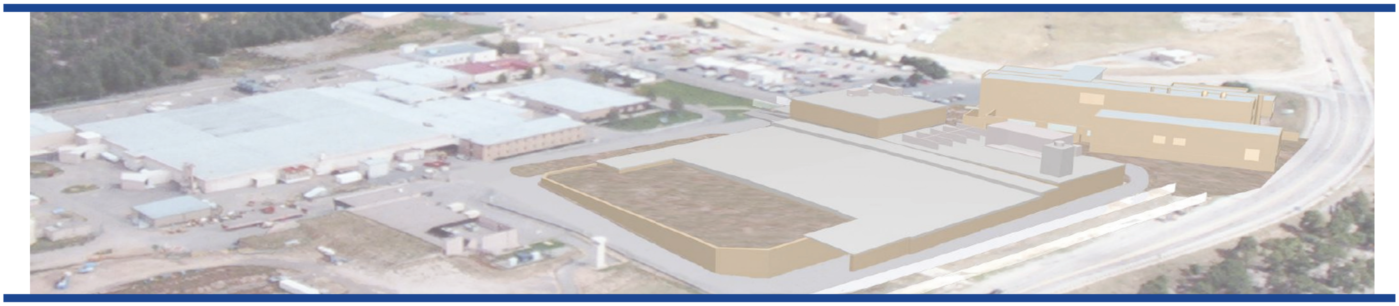
"This work can and will be done in the CMRR when it's complete. It can be done there much more efficiently and effectively because of the facility's modern laboratories and safety and security systems. CMRR is a chemistry and materials science research facility—laboratories—with support facilities such as the Radiological Laboratory/Utility/Office Building. It will host research into nuclear energy, nonproliferation, nuclear safeguards, and nuclear containment and cleanup."

"Complex Transformation is not just about our physical infrastructure," explained D'Agostino when announcing that the two records of decision had been signed. "This is also about how we perform our missions and the people who do it. We must recruit a new generation of talented scientists and engineers for our national security."

Transformation Will Benefit LANL

NNSA's plans for transforming the nuclear weapons complex will be beneficial for LANL. In an environment of steady or reduced budgets, modern facilities will allow LANL to reduce fixed costs and apply a greater percentage of funds to the research that the nation requires and for which LANL is well known.

The experts at Los Alamos must ensure that NNSA's plans are realized in a manner that preserves the institution's capabilities on which the nation depends, especially our science, and seek new opportunities to apply its unique scientific and engineering talents for the nation's benefit. NWJ

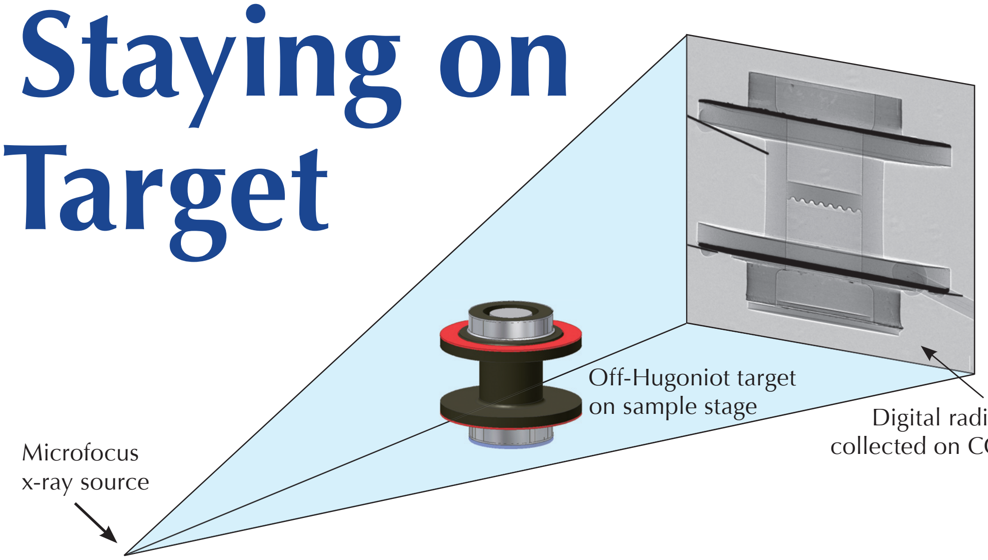


The Complex Transformation Preferred Alternative will consolidate missions and facilities within the existing NNSA sites, known as distributed centers of excellence.

	LANL		LLNL		SNL		NTS		Y-12		SRS		KCP		Pantex	
	☐ Present	☐ Future	☐ Present	Future	☐ Present	Future	☐ Present	☐ Future	☐ Present	☐ Future	☐ Present	☐ Future	Present	Future	☐ Present	☐ Future
Nuclear design and engineering	✗	✓	✗	✓												
Nonnuclear design and engineering	✗		✗		✗	✓										
Supercomputing platform host	✗	✓	✗	✓	✗											
Major environmental testing	✗		✗		✗	✓										
High-hazard testing	✗		✗		✗		✗	✓								
Plutonium	✗	✓	✗													
Tritium operations	✗										✗	✓				
Uranium									✗	✓						
Nonnuclear production													✗	✓		
Weapons assembly and disassembly															✗	✓

☐ Denotes site with special nuclear materials that require the highest levels of security.

Staying on Target



Simplified geometry of the MXCT instrument. To collect a digital radiograph of the sample, the target is placed between the x-ray source and the imaging detector, a scintillator mounted on the front of a charge-coupled device (CCD) camera. The resulting image is stored on a common server for the assembly team to examine in near real time.

Inertial Confinement Fusion (ICF) energy research holds great promise for enhancing scientists' understanding of the nuclear processes at the heart of nuclear weapons and the stars that make up the universe—processes that may one day be harnessed to provide clean energy for powering our cities. But before the benefits of ICF can be realized, a number of technological challenges must be met. The first challenge is achieving ignition, that is, beginning a fusion reaction that eventually produces a net energy gain.

LANL's ICF experiments direct extremely intense laser energy at a target capsule containing deuterium-tritium fuel. The applied energy causes the capsule to implode, compressing the fuel atoms under extremely high temperatures and pressures until some of the atomic nuclei fuse, releasing even more energy. When more energy is produced by the thermonuclear reaction than used to create the reaction, researchers will have achieved nuclear fusion.

To attain ignition, the target capsule must be compressed uniformly to minimize hydrodynamic instabilities that might dissipate energy or otherwise interfere with the fusion reaction. Because of the extreme temperatures and pressures involved, any imperfections in the capsule amplify hydrodynamic instabilities created during experiments.

Using micro x-ray computed tomography and confocal micro x-ray fluorescence for nondestructive examination of fusion targets and their fabrication materials, we can confirm each target's composition and structure.

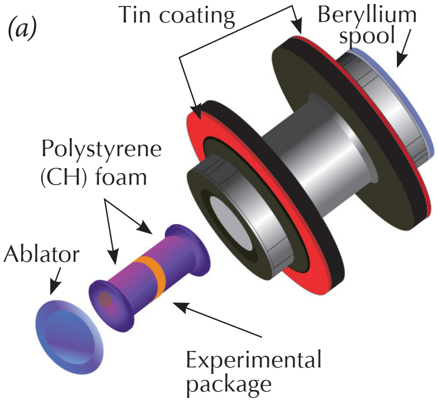
Two New Imaging Techniques for ICF Targets

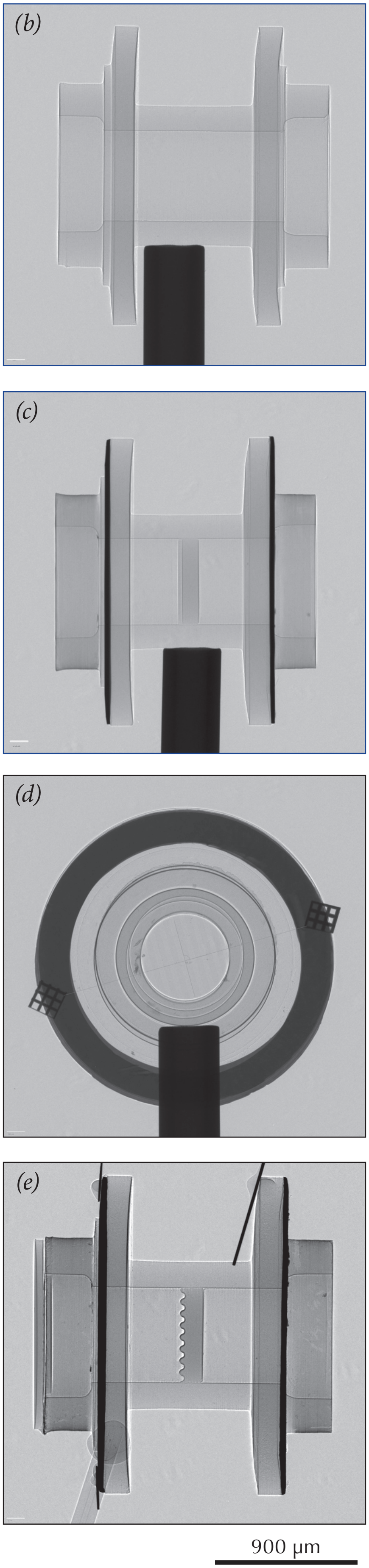
Two complementary new imaging techniques, micro x-ray computed tomography (MXCT) and confocal micro x-ray fluorescence (confocal MXRF), are available for characterizing and imaging fusion targets and fabrication materials. These techniques use x-rays to collect essential information on a sample's structure and composition and to generate 3-D images without damaging or destroying the sample. When used together, they provide a more comprehensive picture of the target or target material than is possible with either technique alone.

Micro X-Ray Computed Tomography

MXCT produces magnified x-ray images (radiographs) of a sample. The images reveal details about the sample's structure that might affect the performance of an assembled fusion target.

The MXCT instrument, purchased from Xradia (Concord, California), shines a cone-shaped beam of x-rays through the sample. The x-rays are attenuated by the various structures and materials in the sample and shine on a scintillator that produces a visible-light image that is magnified and projected onto a camera to generate a digital radiograph.





(a) Cartoon of the off-Hugoniot target and *(b–e)* radiographs of the target during its assembly. Each radiograph took 1 minute to collect. *(b)* An empty beryllium spool (the dark object at the bottom is the vacuum chuck holding the part). At this stage, confirmation of the machining quality is important to ensure that inside edges are square. *(c)* Image taken after a tin coating was applied to the spool (two vertical dark lines in [*c*] and shown in red in [*a*]). The experimental package (orange disk in [*a*]) with two pieces of CH foam (purple in [*a*]) inserted. The image confirms that the foams are completely pressed into position. *(d)* The target was rotated 90° to locate the sine wave on the front of experimental package. The angle from the alignment grids is measured and the target is mounted on the stalk so that the image is horizontal and the sine wave machined into the experimental package is perfectly aligned, as shown in *(e)*, the assembled target. The ablator, which drives the experimental shock, can be seen on the left side of the target.

The MXCT instrument can be used in two imaging modes. In the first mode, the instrument creates quick-turnaround digital radiographs. These real-time 2-D images (each takes approximately 1 minute) are especially useful during target assembly because they allow LANL's Target Fabrication and Assembly Team to quickly identify and eliminate misalignments and other problems.

In the second mode, the MXCT instrument collects approximately 1000 radiographs as a sample is rotated 180°. It then computationally reconstructs the stack of radiographs to generate a 3-D image of the sample. Each volume element, or voxel, in the 3-D image is a computed x-ray absorption profile. A typical 3-D data set is collected in approximately 18 hours.

The two image types are comparable to medical x-rays and computed tomography (CT) scans that provide doctors with valuable information on a patient's bone structure. CT scans deliver a 3-D image of an object calculated from a series of 2-D images taken during a single rotation around a central axis. However, MXCT-generated images are of much smaller subjects and at a much higher resolution than bone scans. Using the current instrument, we can vary the magnification levels, depending on the size of the sample or the feature size of interest. The levels range from low resolution (2× magnification with a 1-cm field of view and a spatial resolution of 20 µm) to high resolution (40× magnification with a 700-µm field of view and a spatial resolution of 0.7 µm). For comparison, the diameter of a human hair is nominally 100 µm.

Ensuring the Quality of Off-Hugoniot Targets

The MXCT instrument is very useful for ensuring the quality of targets for off-Hugoniot experiments. Such experiments, which take their name from Pierre-Henri Hugoniot, the French engineer who explored how shock waves affect flow properties, examine how target defects affect ignition capsule performance—specifically, what happens at material interfaces under heated and shocked conditions.

Despite their small size (<2 mm in length, about the width of a grain of rice), these targets are very complex. They are composed of 18 parts fabricated from a variety of materials, including a 1.8-mm-long machined spool of pressed beryllium, metal foils, polystyrene (CH) foams, plastic end caps, and other pieces containing several very thin layers of metal and polymer coatings. The parts must be machined and assembled to exacting specifications; all parts must line up precisely in the target or the experiment will fail. We use ~25 targets during a typical month-long experimental campaign at the Omega Laser Facility located at the University of Rochester's Laboratory for Laser Energetics.

Off-Hugoniot targets center on an experimental package—in the illustration, the orange disk with a sine wave machined on the front. The sine wave must be perfectly perpendicular within the spool; otherwise, the diagnostics used during the experiment will not have the proper view.

During target assembly, we collect approximately 20 different radiographs of each target to check individual parts for material and machining quality and to ensure that the parts are aligned and assembled correctly. If the images indicate that the foams were not fully pressed into place, allowing the disk to rotate during assembly, the target is disassembled, the foam assembly is repaired, the target is reassembled, and then additional images are made of the target.

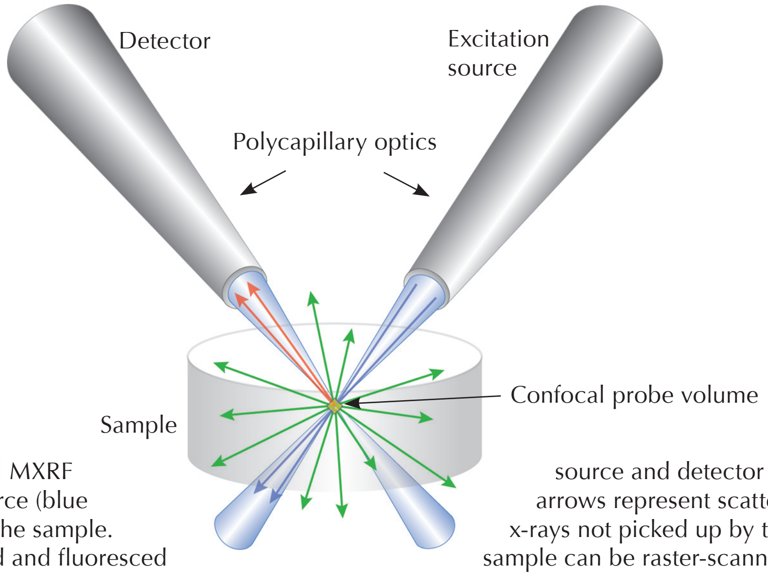
MXCT is also an important characterization tool for other Los Alamos projects, that involve other target types, foams that are static or under compression, and material interfaces. In addition, the instrument is used to image high explosives, novel materials such as nano metal foams, carbon fiber composites, geological materials, and metal tensile specimens.

Confocal Micro X-Ray Fluorescence

Confocal MXRF produces high-sensitivity 3-D density maps of materials and elemental composition maps that not only identify the elements present in a sample but also measure the elements' concentrations and spatial distributions.

Developed at Los Alamos in collaboration with X-ray Optical Systems of East Greenbush, New York, confocal MXRF was designed to examine the elemental characteristics of radioactive materials; our instrument won a prestigious R&D 100 Award in 2004. Our confocal MXRF configuration uses polycapillary optics on both the excitation source and the detector. The area where the two optics' focal regions overlap is called the confocal probe volume. The confocal configuration filters out x-ray signals coming from outside this overlapping region so that only the signals from the probe volume are detected and analyzed.

When microfocused x-rays from the source optic are directed onto the sample's surface or into the sample's interior, some x-rays pass right through the sample. Other x-rays that interact with the sample fluoresce and some of these x-rays are picked up by the detector. The fluoresced x-rays reveal important details about the sample.



Simplified geometry of confocal MXRF instrument. X-rays from the source (blue arrows) are directed on or into the sample. The detector measures scattered and fluoresced x-rays (red arrows) from the confocal probe volume (yellow square), where the focal regions of the excitation source and detector overlap. The green arrows represent scattered and fluoresced x-rays not picked up by the detector. The sample can be raster-scanned in all three dimensions to collect an elemental full spectral map or a density map of the sample in 3-D.

All materials absorb the source x-rays to some degree and respond to the added energy by fluorescing, i.e., emitting new x-rays with lower energies than the source x-rays. The energies of the fluoresced x-rays correspond to the electron transitions of the elements in the sample. Because each element fluoresces at a characteristic energy level, the energy of each peak on an x-ray fluorescence spectrum reveals the elements present. In addition, the height of each peak is proportional to the number of atoms of that element in the confocal probe volume.

Element (line)	Energy range (keV)
Argon (K_α)	2.8–3.2
Titanium (K_α)	4.0–5.2
Chromium (K_α)	5.1–5.7
Iron (K_α)	6.0–6.6
Nickel (K_α)	7.0–7.8
Copper ($K_{\alpha/\beta}$)	7.4–9.1
Zinc (K_α)	8.4–8.9
X-ray scatter (this source)	9.6–36.6

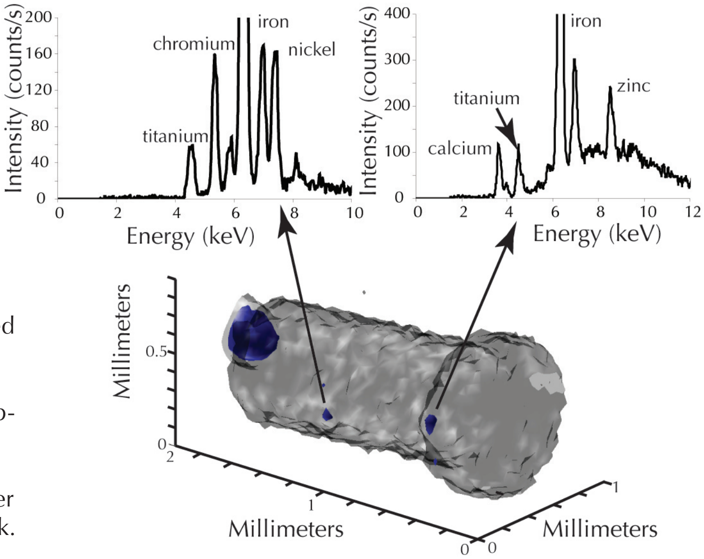
Low-density materials, such as CH foams and silica aerogels, scatter the source x-rays well. Because the amount of scatter is directly proportional to the mass of the material—and therefore the density—inside the probe volume, confocal MXRF can also be used to generate high-sensitivity, 3-D density maps of low-density materials.

Confocal MXRF for Low-Density Materials

Our confocal MXRF instrument can use the scatter from a CH foam sample to generate a 3-D image of the sample's density. If an element with a higher atomic number is present, we can also image it in 3-D. A recent confocal MXRF image shows a piece of CH foam with two metal particulate contaminants. Using confocal MXRF, not only can we determine the locations of the particles (as with tomography measurements), but (unlike tomography) we can also collect an elemental spectrum of each particle.

From the confocal MXRF data, we see that the metal particles are found on the surface, not the interior, indicating that they were deposited during machining and not formulation. From the spectra of the contaminants, we determined that they are two types of stainless steel. The location of these particles on the surface of the foam indicates that only further cleaning of the part is necessary. Without this information, we would have mistakenly concluded that it was necessary to repeat the synthesis process—a much more difficult, time-consuming, and expensive procedure.

Applying the confocal MXRF technique to low-density materials, we confirmed that the amount of scatter is proportional to the material's density. By examining aerogels with known bulk densities, we measured a direct correlation between the amounts of scatter with the bulk density (see the *Nuclear Weapons Journal*, Issue 1, 2007, "Radiation-Driven Blast Waves at Sandia's Z Facility," pp. 3–7). We measured the density of these samples by approximating the volume of the sample with a light shadowgraph and we measured the mass using a standard laboratory balance. Using this technique, we can measure the density to an overall precision of ±2%.



This image of a CH foam with metal particles demonstrates the effectiveness of confocal MXRF in locating and identifying particle contaminants. The spectra show that the particles are two different stainless steels. Maximum signals are 1000 counts and 1500 counts, and the particle sizes measured by confocal MXRF are 60 μm *(left)* and 85 μm *(right)*. The particle sizes measured with x-ray tomography are ~15 μm. The difference between these two size measurements is attributable to the differences in spatial resolution, hence the complementary nature of the two techniques. The large blue area on the far left of the image is a region of very high scatter produced by the glue that holds the foam on a mounting stalk.

Line profiles collected by moving the aerogel sample through the beam revealed startling information. Ultralow density aerogels, with a typical density between 2–120 mg/cm^3 (air and water have densities of 1.2 and 1000 mg/cm^3, respectively), exhibit a large amount of shrinkage during the aerogel drying process and can lose as much as 20% across their diameter. The profiles we show in our illustration are of a single aerogel sample with a density of 37 mg/cm^3.

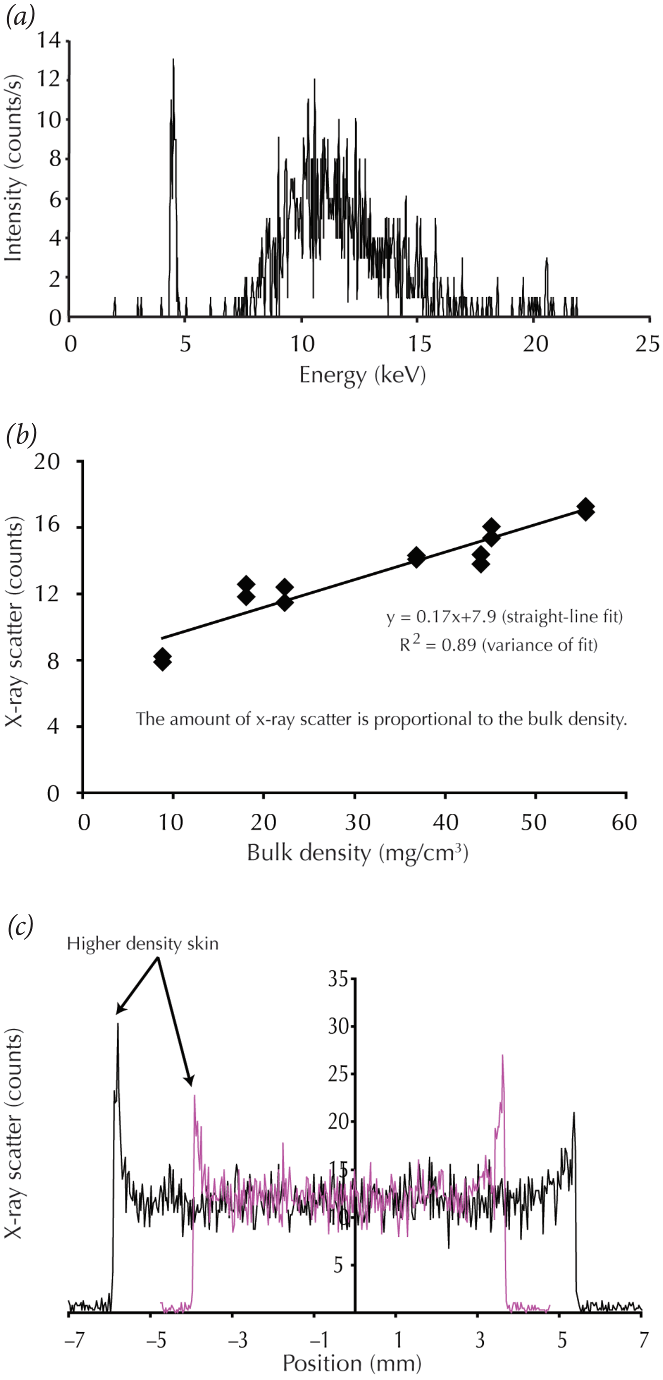
Scientists and the ICF community have known about the shrinkage of aerogels for some time, but it has never until now been measured with this fidelity. They assumed that the shrinkage was evenly distributed through the sample, but our data indicate that the shrinkage occurs primarily at the surface. This new information leaves researchers with two problems. First, the density of the aerogel is not as uniform as that required for physics experiments. Second, the density at the center of the aerogel is lower than that measured with the shadowgraph and balance. Confocal MXRF was not originally envisioned for these types of measurements. The fact that we can make these measurements was completely unexpected and very exciting.

Combining Techniques

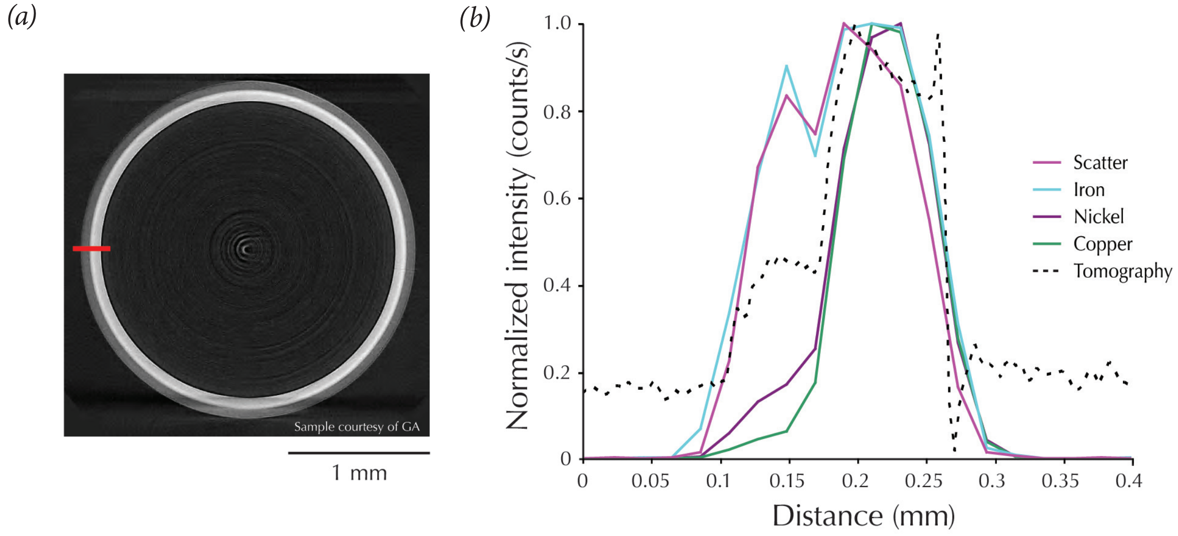
General Atomics manufactured and then loaned us a 2-mm-diameter, copper- and argon-doped beryllium spherical capsule (an ICF target).

As part of ongoing efforts to improve target manufacturing, General Atomics typically follows a multistep process to characterize targets to ensure that manufacturing specifications are met. One such specification might be to keep the argon concentration throughout the capsule below a certain level. First, they would use contact radiography—placing the capsule onto a radiographic film plate—to image it. Next, they would cut the capsule in half (destroying it) to collect an elemental profile of its cross section using a scanning electron microscope (SEM). Then, after using modeling to correct for path changes of a spherical object, they would overlay the elemental intensity profile collected by the SEM onto the contact radiography data. Finally, they would subtract the two profiles to determine the final argon profile.

Using our x-ray tomography and confocal MXRF techniques, we can nondestructively determine elemental composition profiles of the target, leaving the capsule available for further characterization with other techniques such as surface mapping.



Characterization of silica aerogel using confocal MXRF. *(a)* An energy spectrum of the scattered x-rays. Compare with the previous illustration's spectra and the lack of strong elemental lines. Silicon cannot be directly identified because the energy of the fluorescent silicon x-ray is absorbed by air; however, we can detect the effects of the silicon's presence. *(b)* A plot of the amount of scatter produced in relation to the bulk density of the aerogel. *(c)* Two line profiles through a 37 mg/cm^3 density aerogel. The black line is the aerogel as cast in a mold. The purple line is after machining 2 mm from the radius. As a result of void collapse, the aerogel has a higher density skin on its surface.



A copper- and argon-doped beryllium spherical capsule. *(a)* A reconstructed x-ray tomography slice showing the low x-ray absorbance outer shell and the higher x-ray absorbance inner shell. The outer shell is composed of beryllium with ~0.4 at. wt% argon; the inner shell is beryllium with 0.4 at. wt% copper and 0.4 at. wt% argon. Nickel and iron contaminants (from manufacturing) are present throughout.

(b) The graph shows the line profiles (red line in [*a*]) of the cross section from the x-ray tomography (dashed line) overlaid with the elemental profiles from the confocal MXRF instrument. All data profiles are normalized to a value of 1 to facilitate visualization. Future work will focus on moving from overlaying line scans to overlaying full 3-D scans.

By applying confocal MXRF to this same sample, we collected elemental fluorescence profiles through the wall of the capsule. The elemental profiles show that copper is present in the inner portion of the cross section and that iron is present in low amounts throughout the cross section. The iron is a contaminant from the beryllium manufacturing process. Argon is also present, although the argon x-rays are too low in energy to be measured with the current instrument.

Using MXCT and confocal MXRF for nondestructive examination of fusion targets and their fabrication materials, we can confirm each target's composition and structure. Applied separately or together, these complementary techniques are invaluable for providing the thorough characterization necessary to develop new target materials and fabrication methods and for ensuring that experimental targets meet scientists' specifications. The data obtained from experiments using well-characterized targets is invaluable for scientists and engineers working to develop target capsules that meet the challenge of achieving ignition. The few examples of materials and targets presented here are but a small set of the 25 different types of targets manufactured in a typical year; these best illustrate the analysis techniques and how they can be used.

The extreme conditions that exist inside a target capsule during ignition are like those at the centers of stars and of nuclear weapons during detonation. Replicating these processes in the laboratory promises to increase understanding of the conditions and processes at the core of nuclear weapons, which is important for assessing the effects of aging on weapons as part of the Stockpile Stewardship Program and for new weapons research and development. It also promises to increase understanding of the inner workings of the stars so that one day the power of fusion energy can be harnessed to produce abundant clean energy that does not contribute to nuclear waste or nonproliferation concerns.

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George Havrilla, Kimberly DeFriend, Steve Batha, Pat Reardon, Derek Schmidt, Bob Day, Doug Hatch, Brent Espinoza, and the Target Fabrication and Assembly Team.

We also wish to thank Haibo Haung and Abbas Nikroo of General Atomics for the loan of the copper-doped beryllium capsule.

MaRIE to Become LANL's Signature Experimental Facility

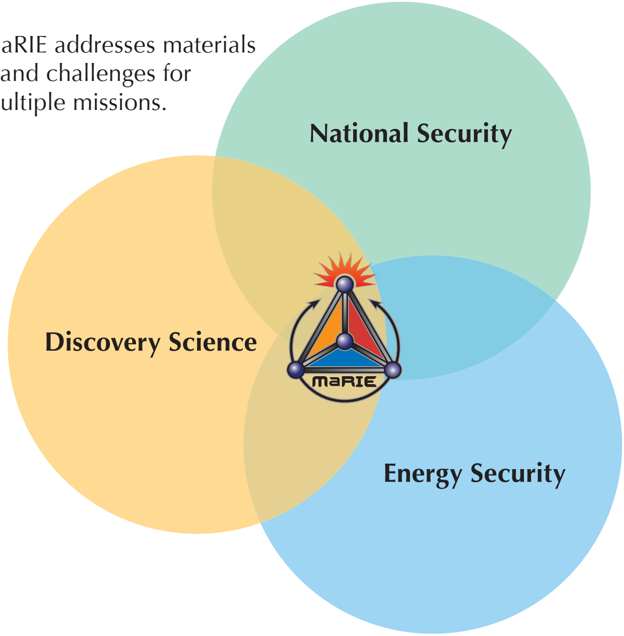
The Matter-Radiation Interactions in Extremes (MaRIE) experimental facility will be used to discover and design the advanced materials needed to meet 21st century national security and energy security challenges. Specifically, MaRIE will provide the tools scientists need to develop next-generation materials that will perform predictably and on demand for currently unattainable lifetimes in extreme environments.

The current inability of scientists and engineers to predictively connect atomic-scale and nanoscale understanding of materials to their performance in real-world components represents a critical obstacle to achieving the performance society needs from materials. MaRIE will provide the experimental tools that, coupled with advances in computational science and theory, will enable breakthroughs in predictability that will allow materials science to move from a focus on empirical observation to predictive design and control. As the first in a new generation of scientific facilities for the materials community, MaRIE will deliver on the promise of transformational materials solutions.

Although MaRIE represents a revolutionary change in scientists' approach to understanding materials, they have an existing facility for guidance—the Los Alamos Neutron Science Center (LANSCE). For more than 30 years, LANSCE has been a tool to advance scientific understanding and solve mission-centric challenges. The Lujan Center's neutron scattering capabilities and proton radiography provide unique probes of matter that have significantly increased understanding of materials performance. Proton radiography experiments provided critical data to resolve issues associated with high explosives in corner turning in extreme cold environments. The Materials Test Station, now under construction at LANSCE, will provide unprecedented capabilities for fast-fission neutron irradiation experiments that are essential for advanced nuclear reactors.

The Micron Frontier

The performance scientists expect and achieve from many materials is presently much less than what they believe the materials' limits to be. This gap reflects scientists' current inability to connect atomic-scale phenomena (limited by computational tools to <1 μm) to bulk, integrated performance (often at dimensions >>1 μm). For example, the strength of a chemical bond has little bearing on how strong an actual material component is or how long it will last in the real world. In fact, the strength of most structural metals is 1% or less than the strength predicted from the interatomic bond strength. The presence of naturally occurring and artificially induced defects and interfaces, many of these realized at roughly a length scale of 1 μm, prohibits the material from achieving its theoretical



MaRIE addresses materials grand challenges for multiple missions.

strength. On the other hand, manipulating and controlling these defects can lead to enhanced performance, e.g., by the deliberate introduction of microstructure through processing methods (e.g., work hardening) to enhance strength.

The change from wrought to cast processing of structural components shows the need to connect atomic-scale understanding of materials to bulk performance. Los Alamos has the capability to make plutonium pits (the triggers for nuclear weapons) with a cast process that produces an appropriately sized and shaped solid directly from a liquid and does so with less waste, equipment footprint, and worker exposure than the wrought process. The US previously made pits with the wrought process, producing right-sized objects with mechanical processing.

Although these two processing methods can yield the same sized and shaped components with similar bulk chemistry, the details of grain structure, morphology, and microconstituent distributions (involving micron-scale features) can (and do) differ. Because the potential effects of these inherent differences on the ultimate performance of the components, particularly in the extreme environments of high radiation and dynamic loading, were not known, LANL performed an extensive and costly experimental and validation program. Ultimately, LASO certified the new process, but the effort drew attention to the materials community's inability to easily introduce a process change such as this. More generally, how a material is made influences its structure on intermediate length scales and this affects bulk performance.

To bridge the micron frontier, scientists need new capabilities to advance understanding and control of materials performance. In general, current incremental progress appears inadequate to solve science grand challenges. Scientific breakthroughs are required to transform approaches to these problems. New models of defect dynamics, new computational tools capable of accounting for micron-scale heterogeneities, and diagnostics that can track these features at appropriate spatial and temporal scales in extreme operating environments are required to enable significant advances.

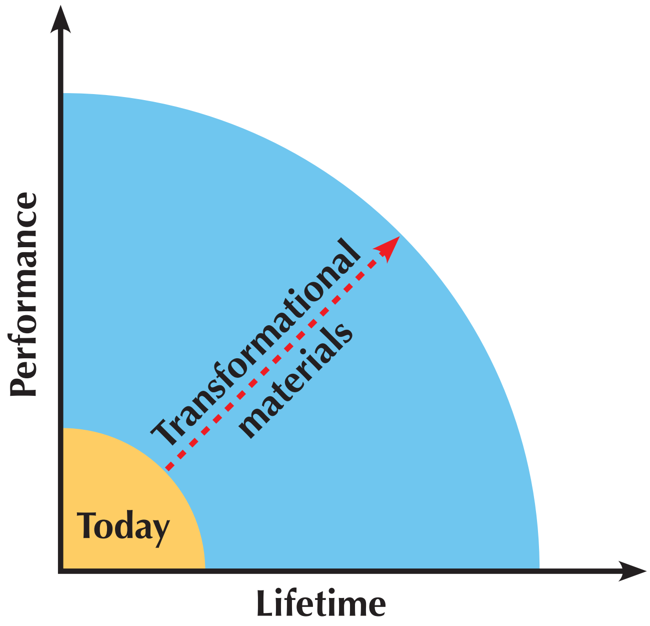
Achieving a fundamental understanding of how processing conditions affect the performance of nuclear weapons presents the same challenges that hinder scientists' ability to solve global renewable energy challenges with scientific discovery. In both cases, materials researchers need to understand phenomena that span multiple length and time scales to advance their understanding of materials performance. In particular, the micron frontier limits researchers' ability to connect high-performance computer simulations on the atomic scale with macroscopic experimental observations. Bridging the micron frontier will be a key focus for MaRIE.

Although MaRIE will be principally an experimental facility, realizing the vision of advanced materials performance requires partnership with the Laboratory's theoretical, information science and technology, and engineering capabilities. Predictive understanding results only from an essential partnership of experiment and theory.

A Process-Aware Understanding of Materials Performance

As scientists consider the future of stockpile stewardship and strive for a smaller, safer, more secure, and more reliable nuclear stockpile, the need for predictive capabilities will guide LANL's efforts. Achieving a process-aware understanding of materials performance, i.e., how materials are made plays an essential role in how they perform, is a grand challenge for scientists' predictive capability. In particular, understanding how radiation damage (a consequence of aging) affects the performance of plutonium is the first of many related challenges. Scientists also need to enhance the safety, security, and performance of next-generation energetic materials.

Scientists will inevitably need to replace aging or obsolete materials and processes with modern processes and approaches. To maintain confidence in the existing stockpile, scientists need to move from producing materials as they always have and certifying their performance through quality assurance methods to a predictive and process-aware understanding



MaRIE enables the transition from observation to control of materials, thereby resulting in transformational performance of materials.

of materials performance. Finally, both to reduce the degree of hazard and to achieve the ultimate extremes of temperature and pressure, scaled experiments will be an important element of future efforts. MaRIE will enable scientists to demonstrate that scaled experiments are accurate and do not overlook essential phenomena that directly influence a material's full performance.

Similar challenges limit scientists' ability to realize the full potential of safe, carbon-free, proliferation-resistant nuclear energy. The potential of next-generation fission plants and possible fusion reactors can be realized far more successfully if scientists can design materials for extreme performance. Based on empirical searches for the best materials, it presently takes more than 20 years to develop and certify a new nuclear fuel or structural material. Predictively designing these materials for the desired performance from first principles will enable more rapid and more rigorous certification. MaRIE will enable a new qualitative approach to achieving predictive materials performance by means of validated product specifications that can assure quality at reduced production costs.

MaRIE Facilities

MaRIE will provide the scientific community with unique capabilities to

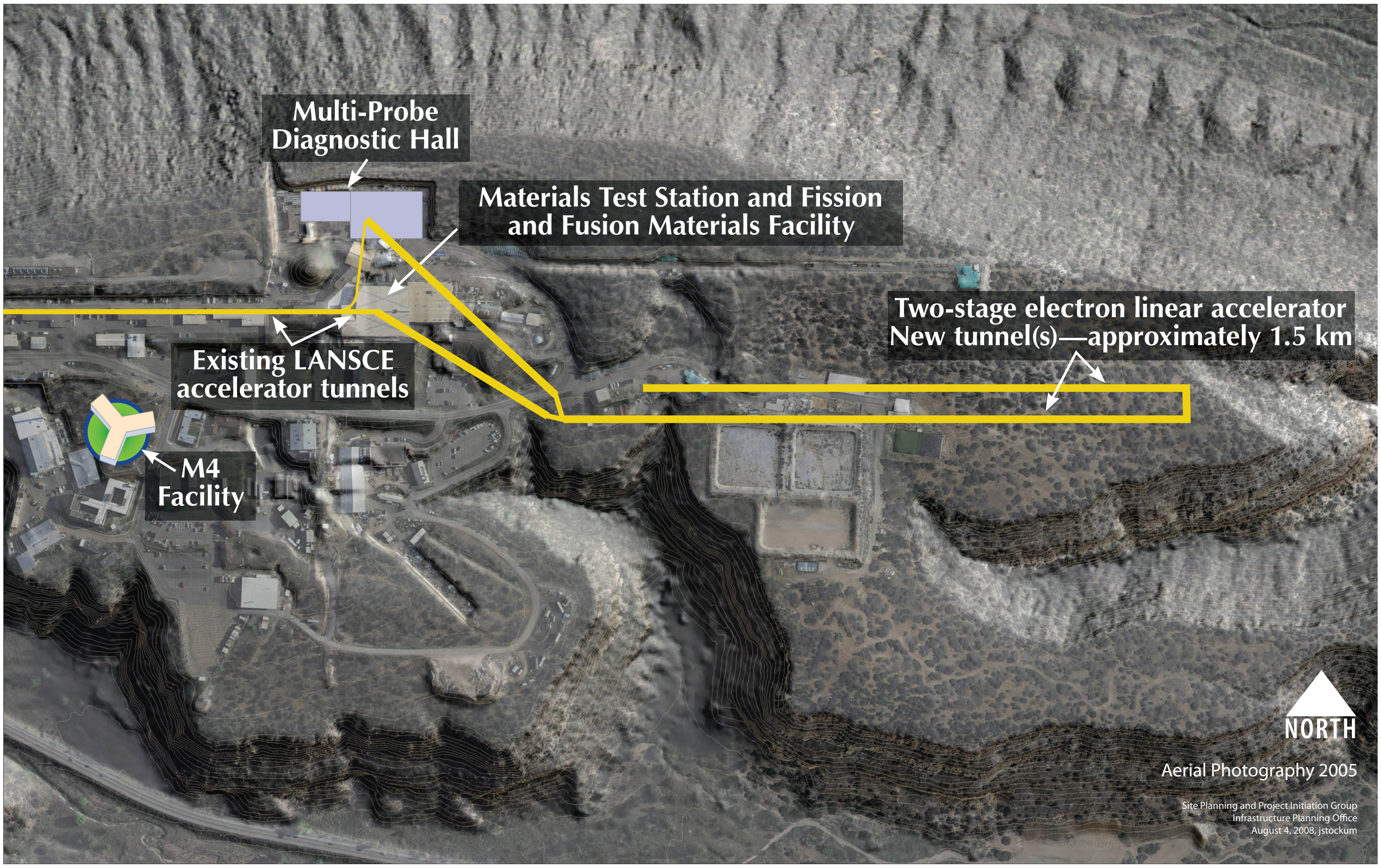
- provide unprecedented time- and space-resolved measurements on the scales most acutely needed for modeling and simulation,
- create extreme conditions of relevance, especially irradiation environments, and
- create the synthesis and characterization tools needed to design, discover, and control materials on these scales.

MaRIE will provide these capabilities with three integrated facilities.

The Multi-Probe Diagnostic Hall will create unprecedented probes of matter, including first-time simultaneous measurements of materials interactions at multiple relevant temporal, spatial, and spectral resolutions using both photon- and proton-based diagnostics. These tools will advance understanding of dynamic materials' performance in regimes from solidification phenomena to turbulence in warm, dense matter.

The Fission and Fusion Materials Facility will provide capabilities for materials irradiation studies. Not only will it be possible to subject materials to radiation extremes that are present in fission and fusion environments, but unique measurement capabilities will also be available to observe radiation damage as it happens. This will advance radiation damage science from scientists performing irradiations and then doing postmortem analyses to scientists making real-time, in situ measurements and tailoring materials to understand and control radiation damage.

The Making, Measuring, and Modeling Materials (M4) Facility will foster discovery by design of next-generation materials that will perform with better durability in extreme environments, e.g., extremes of temperature, strain, or irradiation. M4 will also permit discovery and translation to use of next-generation, integrated solid-state solutions for renewable energy and radiation detection. Translating quantum and nanoscale discoveries for use in practical applications requires the same capability that is required to bridge the micron frontier from atomic-scale understanding to device performance.



Aerial Photography 2005

Site Planning and Project Initiation Group
Infrastructure Planning Office
August 4, 2008, jstockum

Tentative layout of the MaRIE Facility.

Realizing the Vision

As the first in a new generation of scientific facilities for materials research, MaRIE will deliver transformational materials solutions for national security and energy security challenges. LANL's current vision for MaRIE has profited from involvement of its technical staff. MaRIE will continue to involve LANL scientists and must also partner with the external technical community to formulate scientific drivers and facility requirements for MaRIE. These outreach efforts are under way and are vital to ensuring that MaRIE is a unique, world leader for materials-centric national security science. NWJ

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LANL Director Anastasio delivers remarks at the dedication of the National Security Education Center.

The National Security Education Center

LANL Director Michael Anastasio; Principal Associate Director for Science, Technology, and Engineering Terry Wallace, Jr.; and Los Alamos Institute Director Nan Sauer formally united five Laboratory institutes into what is now the National Security Education Center (NSEC). The five institutes are the Engineering Institute, the Materials Design Institute, the Institute for Multiscale Materials Studies, the Information Science and Technology Institute, and the Institute for Advanced Studies. “The goal behind it all,” said Director Anastasio, “is to position the Laboratory as the pre-eminent science institution of the 21st century.”

According to Sauer, forming the NSEC is one milestone on a path toward increased academic cooperation, enhanced scientific collaboration and scholarship, and technical workforce development.

NSEC will focus on developing and enhancing the scientific bases for national security. National security science at Los Alamos has evolved to encompass elements of defense, homeland security, infrastructure and energy security, and the science required for stockpile stewardship. The Laboratory pursues these broad, multidisciplinary programs in order to anticipate America’s national security needs in a changing world.

NSEC’s mission is to help Los Alamos and the nation recruit and train next-generation national security scientists and engineers while revitalizing and retaining the Laboratory’s current world-class technical staff. Maintaining and reinvigorating the current technical workforce is an important element of the NSEC’s mission.

The five institutes within the NSEC focus on technical competency areas critical to LANL’s national security mission. Components common to all five institutes include

- summer schools aimed at recruiting undergraduate students into the graduate school programs,
- research collaborations between academic faculty and LANL staff that employ graduate students and familiarize the students with the Laboratory, and
- graduate course development and delivery using campus faculty and LANL staff as instructors.

Courses are available to LANL staff and on-campus students in NSEC distance-learning classrooms. NSEC will host students, faculty, staff, and visitors from industry in workshops focused on emerging research areas and technologies.

The following sections highlight some areas that these five institutes contribute to the Laboratory’s capabilities in emerging areas of engineering and science.

The Engineering Institute

The Engineering Institute (EI) is a collaboration between LANL and the UC San Diego Jacobs School of Engineering. The scientific thrust of the EI is damage prognosis, an engineering science concerned with assessing the current condition and predicting the remaining life of aerospace, civil, or mechanical engineering infrastructures.

Remote Sensing of Structural Conditions

LANL staff, UC San Diego faculty, and graduate students are jointly developing a new sensor networking strategy. The project is currently focused on detecting damage in civil engineering infrastructure such as bridges—with the goal of averting disasters like the 2007 bridge collapse in Minneapolis. Many novel aspects of this sensor network strategy—including wireless remote power delivery, wireless telemetry, and distributed processing—can also be applied to sensor systems deployed for a variety of defense and homeland security applications such as border monitoring and damage detection in military hardware.

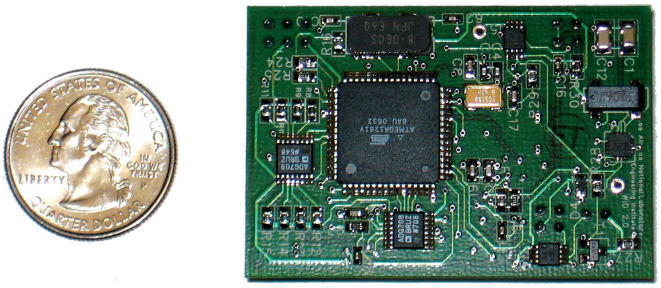
The goal of this project is to develop low-cost sensor nodes (less than $10 per node when mass produced) that, when coupled with statistical pattern-recognition algorithms, will be able to identify incipient damage and give enough lead time for preventive maintenance to avert catastrophic failures. Engineers can adapt this approach to damage detection to all types of civilian- and defense-related engineering infrastructures.

To meet this goal, EI researchers developed sensors that are remotely powered by microwaves to measure and store the bridge peak deflection, i.e., movement resulting from stress. A postgraduate student mentored by LANL staff also developed a smart washer that can monitor preload in the bridge's bolted connections using active sensing techniques. The term active refers to the ability of the sensor to also act as an actuator and apply a mechanical force to the structure that is tailored to enhance the damage-detection process. This smart washer is remotely powered by microwave energy. The microwave source is brought to the vicinity of the sensor using a commercial remote-controlled helicopter retrofitted for this project.

An antenna mounted near the sensor node receives microwaves from the helicopter and stores this energy in a capacitor. Once the sensor node receives enough energy, it takes a reading and broadcasts that reading to a small computer on the helicopter. The computer analyzes the data and classifies it as corresponding to a healthy or damaged structure. Then the helicopter flies to another sensor node and repeats the process. Currently, the sensor nodes, designed at LANL and UC San Diego, are about the size of a credit card.

A major difference between this sensor networking approach and other embedded sensor networks is that EI's system does not require battery power at the sensor

This remote-controlled helicopter can simultaneously interrogate small sensors embedded throughout a bridge's structure and, with an onboard microwave generator, provide the sensor with the power to make a measurement and relay the data to the helicopter's receiver. The helicopter unit then transmits the information to the operator's laptop computer. Once the sensors have been emplaced, the operator can rapidly survey the structural health of the bridge from safety. (The helicopter's rotor span is approximately 2 feet.)



A photo of the actual sensor node. Dozens of these inexpensive sensors can be placed throughout a bridge's structure to measure the stresses that will accurately indicate the structure's health.

node. Batteries eventually lose their power and they have a limited number of recharge cycles. Long-term, autonomous embedded sensing cannot be realized by sensor nodes with such limited-life components. Also, in civilian applications such as monitoring a large suspension bridge for earthquake-induced damage and in many defense applications associated with hostile environments, it can be very hazardous for a human to replace a sensor's battery. In addition, a bridge or other structure would need perhaps hundreds of sensors to accurately measure its health.

In addition to the microwave-powered systems, the LANL/UC San Diego team is experimenting with other sensor node power strategies. One strategy is to retrofit the helicopter with a light source that would focus a small laser on a solar array connected to the sensor node. In another strategy, the team developed processes to harvest the mechanical vibration energy caused by traffic loading to transform it into electrical energy. The EI team envisions that the final sensor node design will incorporate a hybrid approach that couples several of these power strategies to eliminate the need for batteries in embedded sensing systems.

This research project requires multidisciplinary technology development involving structural, mechanical, and electrical engineers working with computer scientists to turn these new sensor network concepts into working field demonstrations.

Civil engineers must now work with electrical engineers and computer modeling and simulation scientists to bring this damage-monitoring technology together. Researchers must learn to interpret the data coming from the deployed sensors to determine if a structure is damaged or requires maintenance.

The bridge damage-monitoring project demonstrates EI's approach to promoting multidisciplinary engineering research projects that can be applied to high-consequence civilian applications and that promote fundamental technologies necessary for LANL to meet its national security mission. In the process, LANL and UC San Diego are training next-generation engineers.

The helicopter delivers power to the sensor nodes mounted on a bridge structure.

The Materials Design Institute

The discipline of materials design is one that integrates the study of materials composition, synthesis and processing, and structure to achieve a material's desired property or performance in an engineering system. Materials designers work to develop new materials and properties, select materials for applications, or optimize the performance of a material. Materials design is a process to achieve a product.

LANL formed a multidisciplinary educational research collaboration with UC Davis to develop materials competency areas. This collaboration with UC Davis has three technical objectives:

- 3-D materials visualization/large data set manipulation,
- functional and multifunctional materials development and characterization, and
- new materials synthesis and crystal growth.

LANL and UC Davis have made progress in all three areas; recent progress in 3-D materials visualization is highlighted below.

3-D Materials Visualization/Large Data Set Manipulation

Many advanced stockpile stewardship and computational activities include detailed approaches to defining materials behaviors in three dimensions. Defining a material's response at intermediate length scales offers critical information that links length scales from the atomistic to bulk response. Experimentally, techniques that provide either prediction or validation of a material's response as a function of its processing history can provide better quality control and uncertainty margins in its performance. However, the desired intermediate length-scale investigation requires new methodologies to extract this information.

The LANL/UC Davis 3-D microscopy efforts are aimed at producing more rigorous characterization of materials at the intermediate length scale. For example, researchers assemble a 3-D representation of a sample material by collecting 2-D images (or montages of images) of the sample. They image multiple layers of the material by precisely and serially sectioning the sample and completely imaging each layer. They then assemble the images made of each layer in the computer software—stacking the images in exactly the same 3-D orientation that the material was in the original sample. This process provides researchers with a multidimensional view of the material.

LANL/UC Davis must still develop many computational techniques, e.g., computational algorithms from the 2-D images that can recognize features such as grain boundaries, inclusions, second phases, cracks, or voids. The next requirement will be the computational ability to interpolate serial sections for continuous features.

NSEC will enhance the scientific bases for national security science at Los Alamos: defense, homeland security, infrastructure and energy security, and stockpile stewardship.

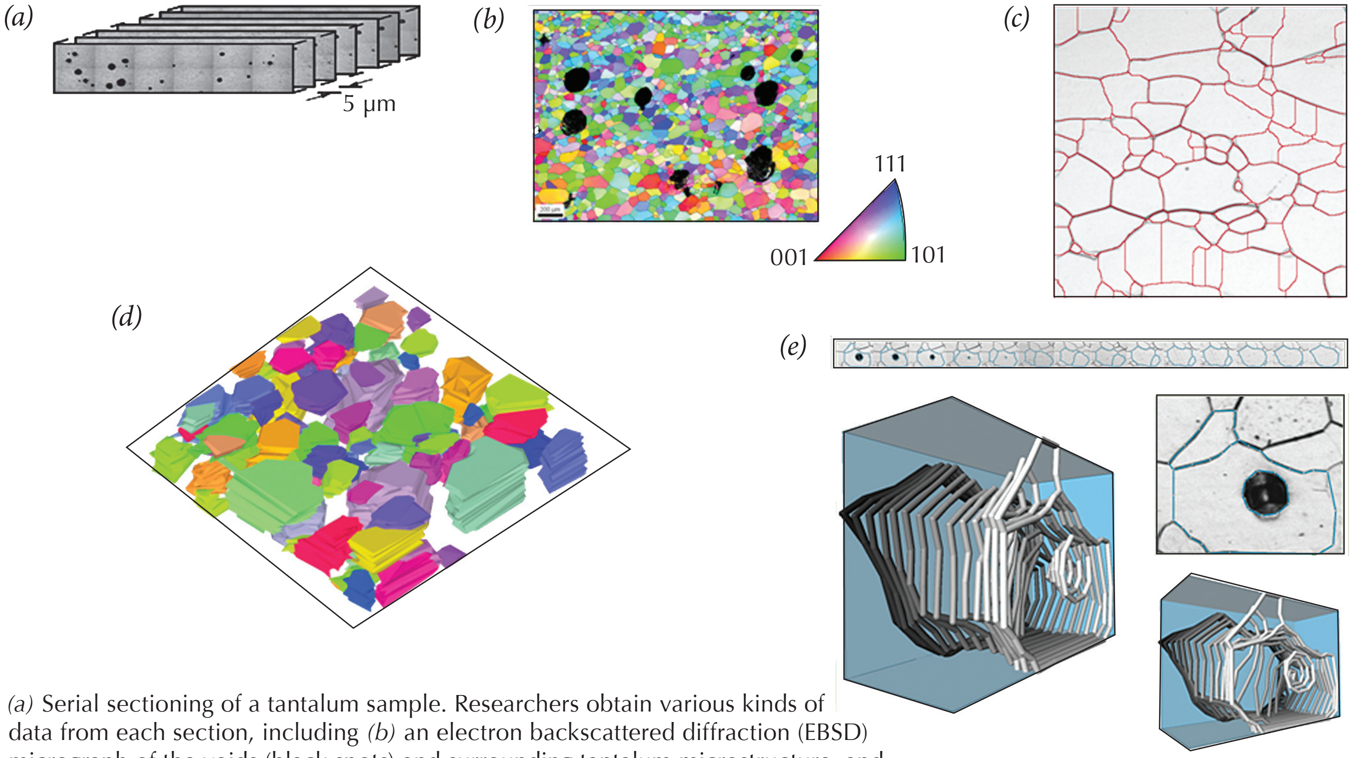
Methods under development to visualize materials use science-based models of physical mechanisms in conjunction with fitting techniques. Moreover, the team must correlate crystal orientation and feature-recognition signatures between the serial sections. Finally, the team must be able to offer 3-D image analysis and data extraction, which researchers are addressing with statistical and theoretical contributions. With all of this information, the collaborators developed an adaptive mesh grid from the near-atomic level (using tomographic techniques from biomedical imaging) to macro images complete with image registration techniques.

Computational methods to link and interpolate imaged sections are an intriguing component of building a 3-D image. These computational methods have unique application to other visualization techniques (only with defined boundary conditions), thus permitting development of more accurate visualizations. All visualization techniques require strategies to eliminate unnecessary information to reduce the size of the data set. In the 3-D image of tantalum, only the crystallographic orientation of the individual grains is retained. As a result, an oriented 3-D description is available to import into other computer codes (e.g., finite element codes) to assemble the aggregates into a bulk system.

The Institute for Multiscale Materials Studies

New Generations of Polymeric Foams

In the past two decades, tremendous research progress has been made at the atomic and nanometer length



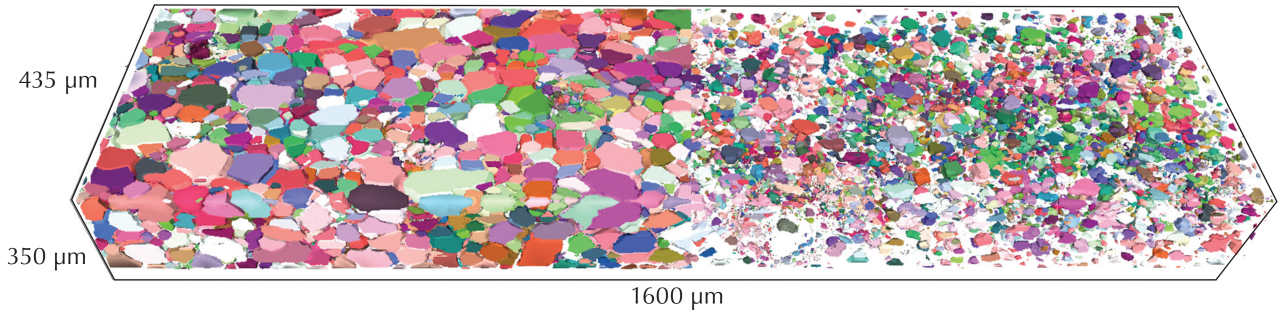
(a) Serial sectioning of a tantalum sample. Researchers obtain various kinds of data from each section, including *(b)* an electron backscattered diffraction (EBSD) micrograph of the voids (black spots) and surrounding tantalum microstructure, and *(c)* an optical micrograph that reveals the segmentation of the tantalum grains. Researchers then combine image analysis of the optical micrograph with the EBSD micrograph to define grain boundaries—even for sections for which they did not obtain EBSD data. They then reconstruct these data into *(d)* a 3-D representation to be used for visualization or *(e)* as input to modeling codes.

scales. One scientific challenge is how to realize the promise of these advances at the component or macroscopic scale, which is being investigated by the Institute for Multiscale Materials Studies in collaboration with UC Santa Barbara. The intent of this collaboration is to learn to control foam morphology during manufacture through molecular parameters such as surface tension, viscosity, and the Flory-Huggins parameter, which describes the interaction energy between two polymers and helps to determine polymer-polymer and polymer-solvent miscibility and demixing potential. Another goal is to learn how the morphological features of the resultant foam, such as density, pore size and size distribution, and aperture size and size distribution, affect the mechanical properties of foams. These activities are critical to developing foam materials with tailored properties for specific programmatic applications such as the life-extension programs of nuclear weapons.

In this multifaceted research project, LANL/UC Santa Barbara is developing methods to characterize polydimethylsiloxane (PDMS) foam materials through x-ray tomography (XRT). XRT uses x-rays to scan 2-D slices of PDMS foam. The researchers then compile the images of slices in the computer software—stacking the 2-D images of the slices in exactly the same 3-D orientation as the original PDMS foam sample to yield a complete 3-D model of the material.

The collaborators developed a graphical user interface in MATLAB for the analysis of the 2-D slices. The MATLAB program steps through each XRT slice and performs several complex image-analysis procedures that result in distributions of cell shape and size, as well as cell centroid position information that can be applied to the entire foam sample. Ultimately, this information will provide insight on the morphological components that most affect mechanical response.

Mechanical response is measured by cyclical uniaxial compression of the same foam samples. During compression, the force exerted by the foam sample is recorded. One goal is to relate the force recorded during deformation with specific morphological changes that occur in foam during compression such as cell wall bending, crushing, and densification. The intent is to produce new polymeric foams with heretofore unrealized macroscopic properties.



This 3-D image is the end result of the 3-D visualization technique. The image contains information from 71 serial sections of a shocked tantalum sample, 17 of which have orientation data. Grains are separated by >15° misorientation. For each grain, the most likely crystallographic orientation has been computed with confidence intervals. Grain orientations are mapped to color. In this image, grains on the right half of the sample have been shrunk 50% to illustrate the density of grains.

The collaboration is currently developing a compression fixture that can be used to deform foam samples in real time during XRT data acquisition. For the first time, researchers will be able to conclusively relate deflections of specific foam morphologies (bending, buckling, and crushing of foam struts; closure of apertures; and deformation of cell shapes) to stress behavior. This information will help determine the most important foam parameters in relationship to load deflection behaviors that can be used to specifically tailor foam components.

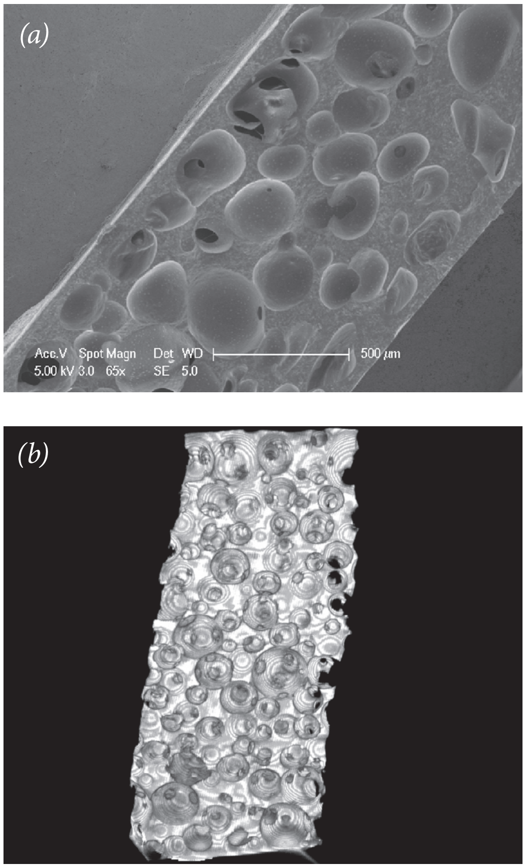
The Information Science and Technology Institute

The Information Science and Technology Institute investigates information science and technology, computer science, and computational science. This institute currently has two technical focus areas tied to LANL's needs in high-performance computing. LANL has initiated the Institute for Reliable High-Performance Information Technology (IRHPIT) with Carnegie Mellon University (CMU) and the Institute for Scalable Scientific Data Management (ISSDM) with UC Santa Cruz. These two institutes are concentrating on joint collaborations that will lead to external joint-funding opportunities.

The Institute for Reliable High-Performance Information Technology

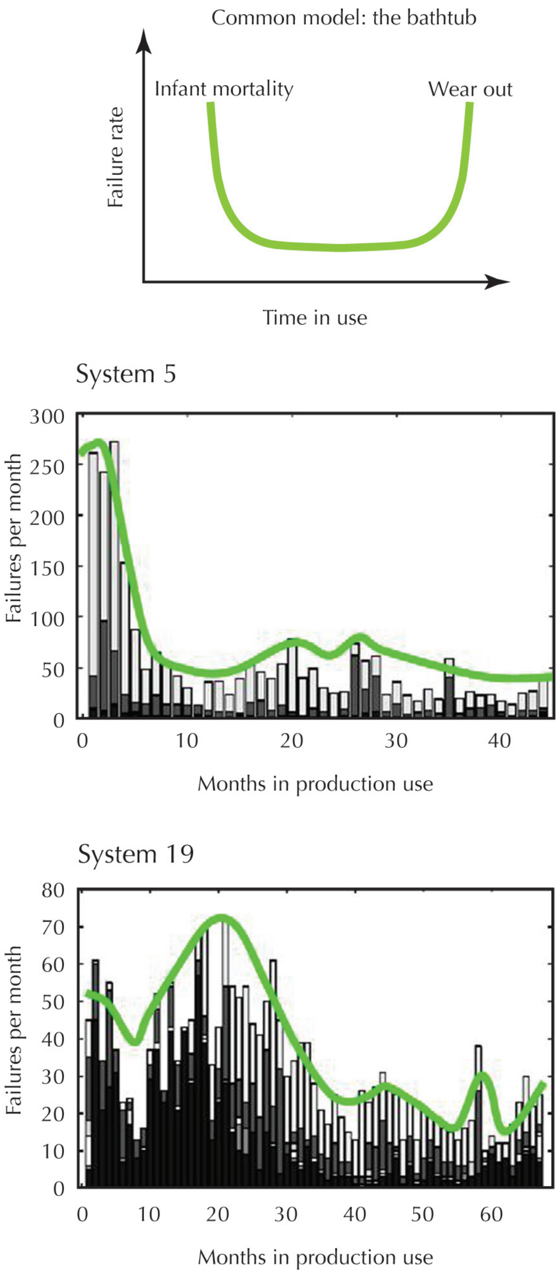
The IRHPIT is an educational collaboration between LANL and CMU's Parallel Data Lab (PDL) and Software Engineering Institute that focuses on reliable high-performance computing. As the sizes of processing chips decrease from 90 nm to 35 nm, as storage devices reach terabyte capacity, and as networks surpass transmission speeds of 10 Gb/s, many current paradigms for protecting data from corruption begin to break down. Most current data-reliability protection schemes are more than a decade old and were not designed for these small feature sizes, large data-storage capacities, and fast data-transmission rates. The IRHPIT explores new paradigms in reliable computing.

As an example of the IRHPIT's work, LANL released much of its computer center operations data, including 9 years of computer-



(a) A scanning electron microscope (SEM) image and *(b)* an XRT image of foam materials. The SEM image looks at a thin foam sample from the end. Note the skin layers on both the top and bottom of the foam. Slices from the *(b)* full XRT image can be analyzed for important cellular parameters, including cell size and shape and distributions of size and shape. The analysis will help elucidate the relationship and bridge the gap between mechanical and morphological properties of high-density foams.
(XRT image courtesy of B. Patterson, MST-7).

failure data, to the computer science community by means of the IRHPIT Web page. This unprecedented release dwarfs all other computer-operation reliability data releases by more than an order of magnitude.



Before LANL's large release of failure data, conventional wisdom in high-performance computing research was that failures of systems would follow the bathtub curve in which systems would fail more at the beginning of their lives due to hardware infant mortality and more at the end of their lives due to hardware wear out. The failure data from two LANL systems depicted in these graphs challenge this conventional wisdom for the first time.

CMU's PDL researchers, in collaboration with the LANL High-Performance Computing Division, analyzed these data and published groundbreaking papers that challenge conventional wisdom about computer failure intervals and trends. These papers won awards at the Institute of Electrical and Electronics Engineers/International Federation for Information Processing International Conference on Dependable Systems and Networks and the Advanced Computing Technical Association (USENIX) File and Storage Technologies Conference.

Interest in the LANL data is very high; several hundred users download data from the IRHPIT Web site each month. In addition, LANL's data release has spurred other sites, including the Pittsburgh Supercomputing Center, Lawrence Berkeley National Laboratory, an internet service provider, and Google, to release computer operational data. To help researchers navigate this new wealth of operational data, USENIX has created a Web site that provides an index of sites' operational data releases.

The Institute for Scalable Scientific Data Management

ISSDM is an educational collaboration between LANL and UC Santa Cruz. The computer science community contends that sensors will generate more data than any other data source in the next decade. Homeland security and defense applications alone will generate terabytes of data every hour of every day from thousands of sources. Given this massive volume, humans will not be able to effectively process, analyze, and make use of these observational data. New paradigms are needed for fusing, analyzing, and manipulating very large data sets in near real time and quickly finding specific information.

ISSDM currently has eight joint LANL/UC Santa Cruz projects involving four LANL divisions and eight UC Santa Cruz students.

Image and signal sensors collect data at increasingly greater rates, making it a great challenge to search and organize data in archives. Manual analysis of all data is not practical, and manual development of highly specialized algorithms is time-consuming, error-prone, and expensive. In one ISSDM project, the Space and Remote Sensing Group of LANL's International Space and Response Division is working with UC Santa Cruz postgraduate students to extract features from images and signals—features can be defined as portions of an image or signal that a customer determines are significant.

Our researchers are working to engage the sensor, data management, and machine-learning expertise of LANL and UC Santa Cruz to tackle adaptive, content-based searches in large remote-sensing archives. This work demonstrates the utility of a new method for extracting features from imagery and signals to alleviate the archival search problem.

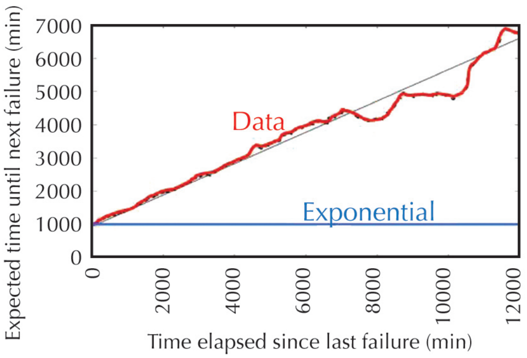
The feature-extraction process is automated using grammars, which are the rules governing the order, or syntax, of elements in a statement of computer code. In this case, the grammars enable the intelligent feature-extraction architectures to be expressed in a compact syntax. The results of this work were applied to a data set obtained by the Fast On-orbit Recording of Transient Events (FORTE) satellite. An ISSDM student developed the language/grammar/syntax to tell computers how to find lightning in images from FORTE data sets more efficiently and more accurately than previous efforts. The grammar-guided approach has also been extended to pixel classification of imagery.

The Institute for Advanced Studies

The Institute for Advanced Studies (IAS) is the newest institute within NSEC. Formed in 2006 under a teaming agreement between the New Mexico Consortium (NMC) and the Laboratory, the IAS goal is to develop research and educational collaborations between LANL and the three NMC universities: the University of New Mexico, New Mexico State University, and the New Mexico Institute of Mining and Technology. Toward this goal, the IAS is working to actively involve students, faculty, and staff from the institute with a broad range of LANL's scientific programs.

To develop these collaborations, the IAS has sponsored workshops and conferences. Topics included nuclear safeguards, isotopes and imaging, neural computation, quantum-enabled science, and cosmology. The Nuclear Safeguards Symposium was of particular interest to the nuclear weapons community. The symposium celebrated 40 years of safeguards at LANL, shared insights about the challenges to safeguards, and discussed the possible direction for the next 40 years. The conference brought together participants from US universities, DOE national laboratories, international safeguards organizations, and industry.

In 2007, the IAS educational activities included summer schools in data-driven modeling and analysis and quantitative biology. Additionally, in collaboration with the UC Santa Cruz Information Science and Technology Institute, the IAS cosponsored the Computer System, Cluster, and Network Management Summer Institute. This institute was designed to educate and recruit undergraduates as large-scale computer system operators and administrators and help supply LANL with technical staff. The school provided practical skill development in setting up, configuring, administering, testing, monitoring, and scheduling computer systems, supercomputer clusters, and computer networks. The summer program also developed students' teaming and communication skills and provided exposure to a variety of key topics and technologies through participation in tutorials, seminars, and facility tours.



Before LANL's large release of failure data, conventional wisdom held that failures among parts of a large system would follow an exponential curve, which implies that past failure is no predictor of future failures. The LANL data directly contradicts this conventional wisdom; it shows a strong correlation between past failure and future failure. In fact, past failure is the highest predictor of future failure in real use of systems.

In 2008, the IAS sponsored an international workshop on biononproliferation and a national workshop on radiochemistry education, and it cosponsored undergraduate summer schools in quantitative biology and in computer system, cluster, and network management.

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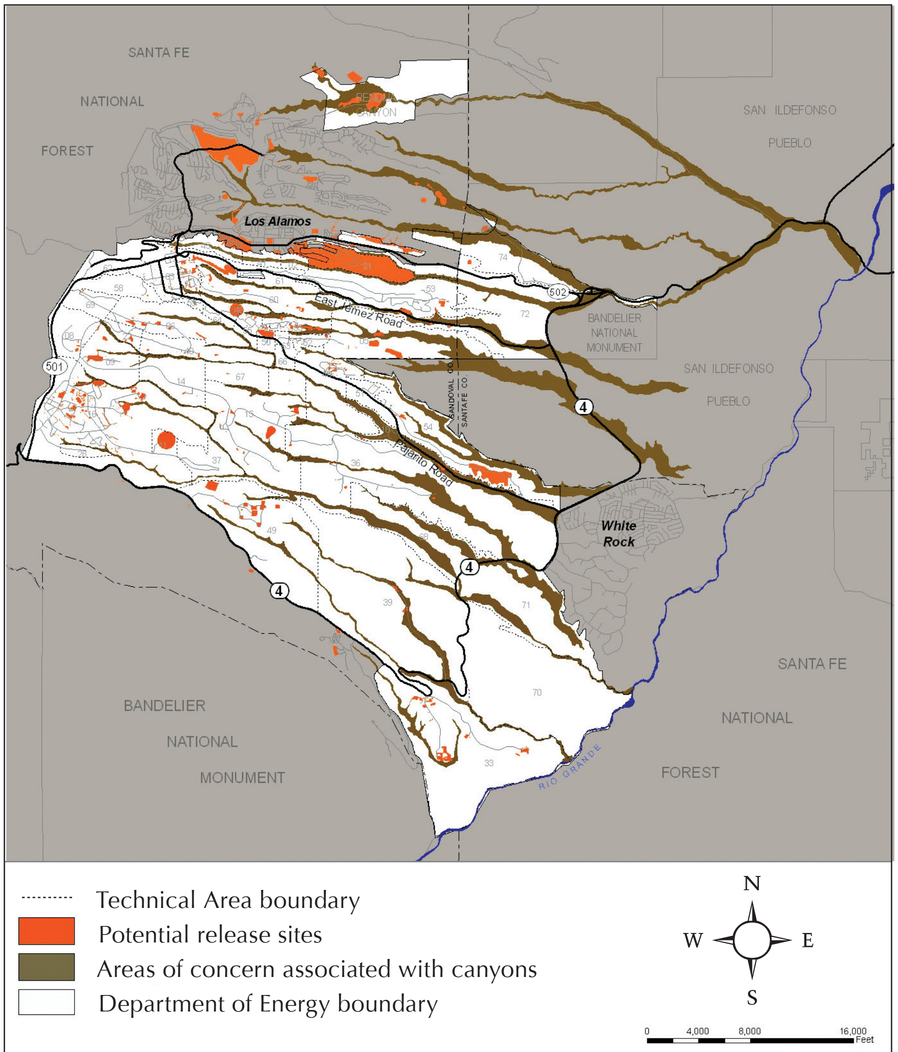
Environmental Cleanup

Historic practices for managing solid waste and wastewater releases resulted in widespread chemical and radioactive contamination of the environment at LANL. Areas adjacent to LANL, such as the Los Alamos townsite and canyons north of LANL's current northern boundary, are also impacted because they were once part of the Laboratory or because contamination has been transported by water or wind.



The Los Alamos area with potential release sites and areas of concern associated with canyons highlighted.

Source: Potential Release Sites; Los Alamos National Laboratory, Waste and Environmental Services Division. Environmental Data and Analysis Group; EP2008-0224, 1:2500 Scale Data; 30 May 2008. Disclaimer: This map was created for work processes associated with the Environmental Cleanup of Los Alamos. All other uses for this map should be confirmed with LANL ADEP-WES staff.

At most locations, concentrations of contaminants in soils are believed to be below action levels established by the EPA and the State of New Mexico to protect human health and the environment. Action levels apply to subsurface and ground surface soils; both are characterized during cleanup investigations. However, contaminant migration into storm water and groundwater has resulted in concentrations that exceed federal and State of New Mexico water quality standards at some locations. Contaminant migration into canyon bottoms and groundwater also greatly increases the work required to characterize the nature and extent of contamination and to remediate past releases of contaminants to the environment.

Groundwater contamination in the aquifer beneath Los Alamos that is used for drinking water is a major concern. Contamination has been identified in that aquifer at several locations, including a location where chromium contamination is 16 times the New Mexico drinking water standard, but wells used to supply drinking water are not impacted. Transport of plutonium contamination to the Rio Grande is also a major concern even though contamination levels are well below applicable environmental standards.

Cleanup Efforts

The Laboratory demolished buildings and cleaned up contamination to the standards of the time, including most Manhattan Project process buildings constructed after 1943, in what is now downtown Los Alamos. The Laboratory began sampling studies and the first modest cleanup of the area in 1946. Early cleanups were primarily for radioactive materials. Cleanup during the 1960s focused on the townsite. As the Laboratory developed, nearly all facilities were moved across Los Alamos Canyon and the townsite developed as a residential and business center.

The current LANL environmental cleanup program began in 1989 with an effort to identify past waste disposal sites where contamination may have been released to the environment. The environmental cleanup program identified a total of 2129 potential release sites (PRSs) for further investigation and possible cleanup, which includes many sites that had been previously cleaned up for radioactive materials. PRSs include historic processing facilities, experimental sites such as firing sites, waste storage areas, historic spills, wastewater systems (including drain lines, discharge points, surface impoundments, and septic tanks), solid waste dumps or landfills (called material disposal areas [MDAs]), and leaking storage tanks. Because contamination is often transported from these sites, environmental media such as soils, canyon sediments, surface water, and groundwater also constitute PRSs that must be investigated.

Types of contamination include chemical constituents such as metals, solvents, fluids used in electrical equipment, high explosives and their degradation products, and radioactive elements, e.g., americium, plutonium, strontium, tritium, and uranium. The corrective action process includes reviewing historic records, sampling, analyzing samples for specific chemical and radioactive constituents to determine the nature and extent of contamination, and comparing analytical results with screening criteria to determine the cleanup remedy.

Manhattan Project buildings around Ashley Pond in 1957.

In early cleanups, PRSs were first assessed as individual units and, if necessary, remediated as individual units. LANL based cleanup decisions solely on a site's potential to adversely impact human health. In 1998, LANL began considering the relationship of PRSs with nearby and downstream sites and their combined impacts on an entire watershed or natural drainage system. The cleanup program also began to focus more on air and water quality and began to assess potential impacts on ecological receptors (plants and animals).

Regulatory Framework

Major environmental statutes enacted by Congress during the 1960s and 1970s resulted in stringent environmental standards and the regulatory framework that drives current environmental cleanup. The Clean Air Act of 1963 as amended in 1970 and 1977, the Clean Water Act of 1972, and the Resource Conservation and Recovery Act (RCRA) of 1976 as amended by the Hazardous and Solid Waste Amendments (HSWA) in 1984 are particularly important at LANL. Executive order created the EPA in 1971. Also important is the Atomic Energy Act, first enacted in 1946, which continues to be the primary statute for regulating radioactive materials and makes DOE the regulator of radioactive contamination resulting from defense activities at DOE sites.

HSWA amendments to RCRA required the investigation and cleanup of sites that were historically contaminated by hazardous materials, with EPA as the regulating authority. DOE regulates sites contaminated only by radioactive materials and is responsible for the radioactive component of sites that have both chemical and radioactive contamination.

EPA was the regulating authority under HSWA for cleanup at LANL from 1989 until the New Mexico Environment Department (NMED) assumed authority for cleanup in 1996. In 2002, NMED issued an Imminent and Substantial Endangerment Order regarding environmental contamination in and around LANL. The Department of Justice challenged this order in federal court on behalf of DOE, and the University of California (UC) challenged the order in both the federal and State of New Mexico courts. Settlement negotiations began in 2003 and resulted in agreement on a draft Order on Consent (Consent Order). The NMED, New Mexico Attorney General, DOE, and UC signed a final Consent Order in March 2005 after DOE and EPA signed a Federal Facility Compliance Agreement for monitoring and control of contamination in storm water runoff from PRSs.

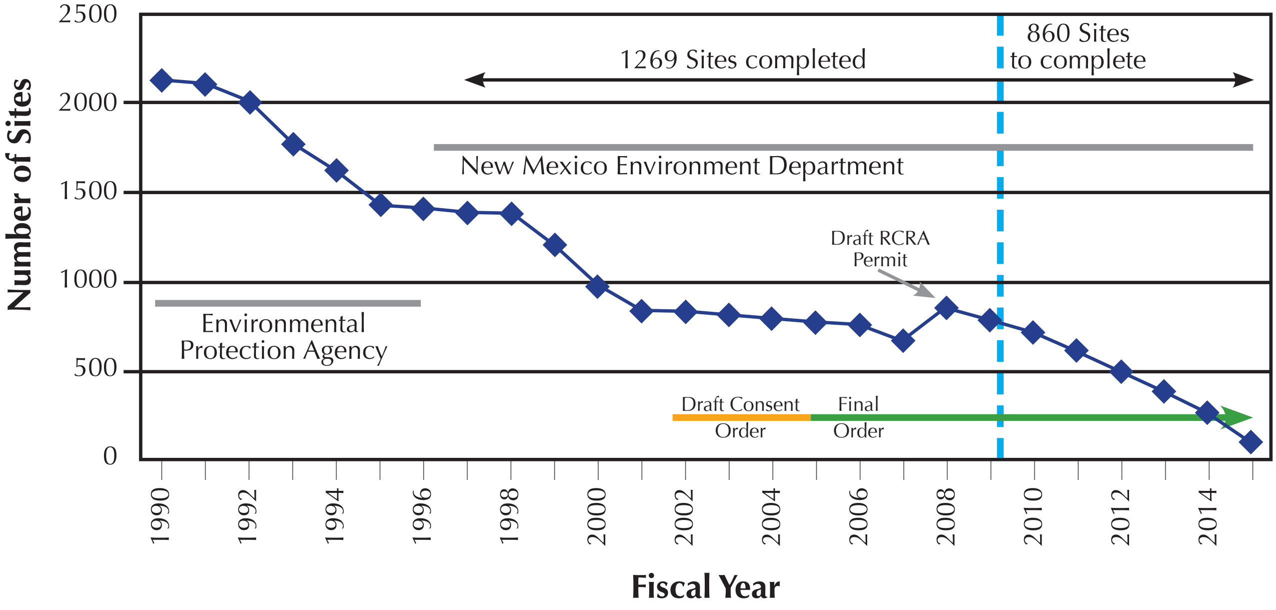
Los Alamos National Laboratory greatly improved its compliance with all applicable environmental requirements over the past 30 years.

Although DOE continues to be the regulatory authority for radioactive constituents, NNSA agreed to provide all information on radioactive constituents to NMED and the public. The LANL cleanup program began to comply with requirements of the draft Consent Order even while negotiations were ongoing in 2003. Los Alamos National Security, LLC, became responsible for compliance with the Consent Order after assuming the management and operating contract for LANL in 2006. The purpose of the Consent Order is to

- accelerate the pace of characterizing the nature and extent of releases from contaminants;
- provide investigation requirements that lead to remedy decisions and determine the order in which investigation activities are conducted;
- prescribe cleanup levels for all environmental media and acceptable risk levels when cleanup is completed;
- prescribe an enforceable schedule for work plan submittals, reports, and remedy completion;
- ensure stable funding to implement cleanup work; and
- complete all cleanup by December 2015.

Analysis, including ecological analysis, is based on a quantitative assessment of risk. Because protection of groundwater and surface water is so important, the NMED will not agree that a site requires no further action until

- results of storm water monitoring show that contamination is within federal and State of New Mexico water quality standards, and
- sufficient groundwater monitoring data are available to support the selected remedy for large sites such as MDAs.



This graph shows the past and projected progress to complete cleanup at the 2129 PRSs that have been identified. Projected progress assumes funding is consistent with requirements of the Consent Order and NMED accepts placing engineered caps as the remedy for most MDAs.

Cleanup levels specified in the Consent Order are intended to ensure that any remaining contamination will not adversely affect

- people who use or intrude on the site (screening criteria for each site are based on future plans for site use such as industrial, residential, or recreational use),
- the nonhuman environment, including animals, and
- groundwater and surface water.

Funding Cleanup

In general, DOE Environmental Management has been responsible for funding LANL environmental cleanup since 1989. Costs from 1997 to completion are expected to total approximately $3.5 billion. Costs include soil and water cleanup, decontamination and demolition (D&D) of buildings on contaminated areas, and disposition of legacy transuranic (TRU) waste.

However, the NNSA Nuclear Weapons Program provides substantial funding for activities that support cleanup. The Weapons Infrastructure Program funds

- facility modifications to reduce wastewater discharges from active operations that are sources of contamination and that affect contaminant transport, and
- facility costs for waste processing facilities that manage hazardous and radioactive wastes generated by all programs at LANL, including the DOE Environmental Management Program.

Finally, the Weapons Program will be responsible for cleanup of facilities and operations that are currently active and have been deferred under the Consent Order.

Cleanup Progress

To date, 1269 PRSs have been completed, but the remaining 860 sites include some of the largest and most complex sites such as 10 of the 26 MDAs. Contaminated groundwater and storm water that may carry contamination from PRSs at levels above applicable criteria must also be remediated.

LANL Cleanup Program Organization

The LANL environmental cleanup program is organized into four projects to conduct cleanup consistent with the Consent Order and to move from characterization to cleanup and finally to environmental stewardship.

MDA B and its proximity to businesses on DP Road. Land already transferred or planned for transfer to Los Alamos County or Los Alamos public schools (outlined with white dashed lines).

TA-21 Closure Project. Project personnel perform all cleanup work at TA-21, where there are four remaining MDAs and a number of other PRSs. One MDA has been remediated. Historic plutonium and tritium process buildings that affect access to some PRSs must undergo D&D before those site investigations can be conducted or remedies implemented. The planned remedy for MDA B includes removing all waste from this disposal site because the site is adjacent to a number of private businesses on DP Road.

Corrective Actions Project. The Corrective Actions Project performs work at all remaining PRSs and six MDAs. Many PRSs have been grouped into aggregate areas that involve major portions of the mesa and canyon systems that make up the Los Alamos area. These aggregate areas include portions of the Los Alamos townsite and eight major watersheds.

MDA G at TA-54 covers 63 acres and is the most critical site for completion by 2015. MDA G is also an active site for disposal of low-level radioactive waste and for storage of large volumes of TRU waste that must be removed before LANL can begin to implement a remedy. The TRU waste is stored in large fabric-covered domes or inside pits, shafts, and trenches dug into the mesa. Closure (under the LANL Hazardous Waste Facility Permit) and D&D of the domes used as container storage areas will also be required before the waste disposal sites can be remediated.

Waste Disposition Project. The Waste Disposition Project performs all activities required to process TRU waste currently stored at MDA G and to process all types of hazardous and radioactive wastes generated before 2013. All TRU waste must be processed to meet the transportation and waste acceptance requirements for disposal at the Waste Isolation Pilot Plant (WIPP), located near Carlsbad, New Mexico.

The total volume of TRU waste to be shipped to WIPP through 2011 is equivalent to approximately fifty-four thousand 55-gallon drums. Almost 25% of that waste is in boxes that are too large for transport and most of the older TRU waste will require repackaging before it can be processed for shipment. Approximately 25% of the total volume of TRU waste is presently stored belowground in pits, trenches, or shafts. Approximately 1% of the total volume is designated as remote-handled TRU waste that requires special handling to comply with nuclear safety and worker protection requirements.

Water Stewardship Project. The Water Stewardship Project characterizes and remediates groundwater and surface water. Environmental data collected by the project will be used to support the remedies selected for the TA-21 Closure Project and the Corrective Actions Project. The NMED required a number of additional monitoring wells to better define the nature and extent of the chromium contamination in Sandia

Almost the entire area of MDA G is filled with old waste disposal pits, shafts, and trenches that LANL will remediate.

and Mortandad canyons and to support the remedies selected for MDAs G, H, and L at TA-54.

Moving to Environmental Stewardship and Sustainable Operations

Los Alamos National Laboratory greatly improved its compliance with all applicable environmental requirements over the past 30 years. However, compliance with all current requirements will not make LANL sustainable in the future from an environmental perspective.

First, environmental standards continue to become ever more stringent and the expectations of DOE, regulators, and the public continue to increase. Second, less mobile environmental contaminants accumulate in the environment and over time may reach concentrations that are of concern. Third, more mobile contaminants are transported into canyons and ultimately into groundwater or off-site into the Rio Grande. Transport of contaminants into drinking water is of great concern even if contamination is far below environmental standards.

The Laboratory established the Environmental Governing Policy that includes a commitment to environmental stewardship and pollution prevention in addition to compliance with regulations. Several goals are being considered that would demonstrate strong commitment to environmental stewardship. These goals include

- eliminating all wastewater discharges to the environment or "zero liquid discharge,"
- using containment vessels for experimental activities that involve open detonation of materials such as uranium, and
- disposing of some LANL-generated low-level radioactive waste at the Nevada Test Site or commercial sites located out of state.

There were 141 permitted wastewater discharges in 1993 and now there are 16. The new permit limits that will take effect in a few years are so restrictive that it may be less costly to eliminate many remaining discharges than treat the water to the new standards. Even discharges of clean wastewater continue to move existing contamination to canyons and groundwater.

Experiments involving open detonation and disposal of low-level radioactive waste are activities that are of increasing concern to stakeholders and regulators. Actions to substantially reduce or eliminate these activities would greatly increase public and regulator trust and decrease future environmental cleanup.

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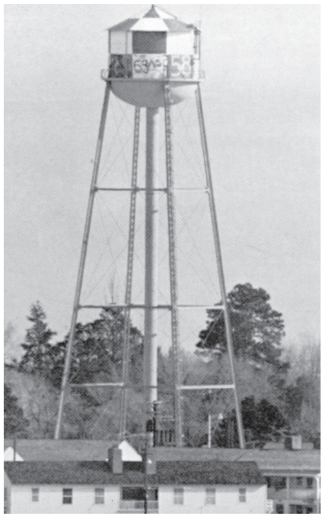
LANL to Receive Economic Stimulus Money

On March 31, 2009, Energy Secretary Steven Chu announced $6 billion in new funding under the American Recovery and Reinvestment Act to accelerate environmental cleanup work and create jobs. "These investments will put Americans to work while cleaning up contamination from the cold war era," said Secretary Chu. "It reflects our commitment to future generations as well as to help local economies get moving again."

The new funding will be used for the decontamination and demolition (D&D) of former weapons complex facilities, transportation and disposal of waste, and cleanup of soil and groundwater. The Department of Energy's Office of Environmental Management, which is responsible for risk reduction and environmental cleanup that resulted from the nation's nuclear weapons program, will manage the cleanup and the funds.

The total funding allotted for New Mexico is $384 million. LANL expects to receive $212 million to demolish 28 buildings and structures, reducing its building footprint by more than 180,000 square feet. The Waste Isolation Pilot Plant (WIPP) in Carlsbad will receive $172 million to accelerate preparation of legacy transuranic waste shipments and shipments to WIPP from several sites.

(Left) Workers remove a plutonium-238 heat source from a "target." *(Above)* Aerial view of TA-21, DP Site (circa 1979).



(left) The water tank before its relocation (circa 1966). *(right top to bottom)* Workers from the plutonium recovery section work at the glovebox line. ◆ A heat source (a mix of plutonium dioxide fuel and a binder) is removed from a press. ◆ DP West under construction, 1945. ◆ View of DP West, showing Buildings 2, 3, 4, and 5 (circa 1947).

LANL 6003

LANL will use the money to complete D&D of vacant Technical Area- (TA) 21 buildings, including the Tritium Systems Test Assembly (TSTA) Facility, and the cleanup and removal of Material Disposal Area B at TA-21.

TA-21, also known as Delta Prime (DP) Site, is located east-southeast of the Los Alamos townsite. After World War II, TA-21 was the Laboratory's main chemical research and plutonium production facility. It processed plutonium from 1945 until 1978. TSTA was used for research on tritium, an isotope of hydrogen used in nuclear weapons, and tritium handling from 1984 to 1999.

Material Disposal Area B is a 6-acre legacy subsurface waste disposal site located on DP Road. It was used from 1944 until its closure in 1948. Because chemical inventories were not kept during this time period, it may contain hazardous and radioactive chemicals and various other wastes.

Laboratory managers anticipate that the economic stimulus money will create 150 or more new jobs and expedite the Laboratory's environmental cleanup programs. Associate Director for Environmental Programs Michael Graham said, "Completing these cleanup activities—in some cases ahead of schedule—will make a real difference in the region and help us get closer to our goal of eliminating hazards from historic operations."

Several WSST members standing in front of a delivery truck tagged with a VPP sign.

Voluntary Protection Program

At Los Alamos National Laboratory, our goal is to provide all workers with an injury-free career," says J. Chris Cantwell, the new Associate Director of Environment, Safety, Health, and Quality.

LANL's Voluntary Protection Program (VPP) supports this goal with active employee-management partnerships to improve employee health, safety, and security. The VPP focuses on prevention with employees and managers solving issues together at the lowest possible organizational level.

Integrated Safety Management (ISM) is LANL's overarching safety program. ISM includes general programs (e.g., worker safety rule, integrated work management, and conduct of operations) and required programs that serve very specific functions (e.g., firearms safety, forklift safety, and lockout/tagout for hazardous energy control). Although these programs provide guidance and requirements, increasing employee involvement and management commitment increases the effectiveness of programs.

What is the VPP?

The Department of Labor's Occupational Safety and Health Administration developed the VPP and used it since 1982. DOE initiated its VPP recognition program in 1994. To be recognized as a VPP site means that LANL successfully achieved excellence in safety and health as a result of employee-driven safety that is coupled with full management commitment. Los Alamos National Security, LLC, instituted the VPP June 1, 2006, when it began managing the Laboratory. The Laboratory will submit its VPP application to DOE-LASO in September 2009 and expects to receive the results of its application by the summer of 2010.

DOE's VPP consists of five elements:

- management leadership,
- employee involvement,
- worksite analysis,
- hazard prevention and control, and
- safety and health training.

Benefits of the VPP

LANL expects to realize the following benefits from safety and health excellence.

- Eliminate or minimize hazards by identifying, predicting, and managing them.
- Improve communication between workers and managers.
- Decrease the number of injuries and illnesses as a result of focusing on event prevention. Since June 1, 2006, the Laboratory has reduced its recordable injury rate by 50%.

- Increase efficiency and productivity. Occupational injuries and illnesses impose a large indirect cost associated with project downtime and reactive corrective actions. These costs are high when compared with costs for a proactive system in which hazardous operations and conditions are identified and corrected before work begins.
- Improve safety and health performance, resulting in greater customer satisfaction.

Employee Involvement

The first VPP initiative promoted workforce involvement by establishing the institutional Worker Safety and Security Team (WSST). The mission of the institutional WSST is to improve safety and security by directly involving everyone who performs work on behalf of the Laboratory.

The institutional WSST membership includes representatives from every Laboratory organization to ensure that workers have an opportunity to become involved in improving safety and security. Director Michael Anastasio fully endorses and champions the WSST.

In addition to the institutional WSST, 100 organizational WSSTs have been established. These teams resolve local issues within their organizations and communicate larger issues to the institutional WSST. Communication flows both ways between the institutional WSST and the local WSSTs. Every worker has the opportunity to be personally involved in the operations and decisions that affect employee health, safety, and security.

Additional employee involvement includes behavior-based safety programs in four high-risk organizations. These safety observation programs promote safe behaviors by identifying risks during voluntary peer-to-peer observations and positive reinforcement of safe behavior.

Management Leadership

Management worked with the institutional WSST to develop 10 safety goals and objectives for FY09. The Laboratory's director, deputy director, and the senior management team approved these goals in January 2009. The goals are as follows:

- increase visibility of the WSST(s),
- expand management's personal involvement in the WSSTs and the VPP,
- increase personal engagement in safety, security, and the environment,
- develop a more widespread implementation of the Human Performance Improvement (HPI) philosophy,
- offer first line managers leadership training that includes the value of the WSSTs and the VPP,
- improve critical thinking,
- recognize and reward employees for excellence in safety, security, and the environment,
- enhance reporting and promote awareness of nonrecordable incidents,
- prioritize institutional WSST and VPP office efforts to meet FY09 VPP milestones, and
- continue to reduce the number of recordable LANL incidents.

Additionally, each organizational WSST has a management champion who ensures the team's success. The champion participates in at least one WSST activity per month and provides the support that is necessary

Distributing the ice scrapers with snow brooms.

YakTrax snow and ice cleats.

Two workers hold up a VPP doormat.

for the team's viability. Management commitment to the VPP provides

- a motivating force and resources,
- safety leadership by example rather than by directive alone,
- a commitment to safety commensurate with commitment to mission and production, and
- clearly articulated safety directions, expectations, and accountability.

To further improve safety, performance, and efficiency, LANL managers are trained in HPI. HPI changes the focus from injury management to injury prevention. Knowing what defenses to build and where to place them shows employees that mistakes are predictable and preventable and that mistakes can be kept from becoming significant accidents. Because we make inconsequential mistakes all the time, we can predict what the consequences might have been under different circumstances. Some mistakes are essential to building and maintaining defenses that reduce the consequences of future mistakes. In other words, mistakes help put the right defenses in the right places, which is key to the VPP.

> **"At Los Alamos National Laboratory, our goal is to provide all workers with an injury-free career." —J. Chris Cantwell**

Management has also shown leadership by placing new emphasis on safety and health performance when selecting LANL contractors, increasing employee recognition for safety and security contributions, and empowering employees to raise and help solve local issues.

Highlights of WSST Activities

During the WSST meetings, safety and security ideas or concerns are expressed by each team member and logged in the WSST action log, which all LANL employees can access on the Web. The WSST assigns each issue a point of contact and a priority and then tracks its status. If it is necessary to vote for any reason, the WSST chair calls for the vote and the majority rules.

Safety concerns resulted in the Laboratory purchasing safety items for distribution to all organizations.

YakTrax Walkers

Slips, trips, and falls on Laboratory property seriously injured more than 60 workers from June 2006 to January 2009, with many falls occurring on snow and ice. In FY08 and FY09, management purchased more than 8000 pairs of YakTrax snow and ice cleats, which are slipped over regular shoes to increase traction on packed snow or ice. The VPP office and WSST members distributed the YakTrax to all workers who requested them.

Ice Scrapers with Snow Brooms

In preparation for winter driving, the LANL VPP office purchased extendable ice scrapers with snow brooms to clear the windshields of government vehicles. Property management personnel distributed the combination scrapers to vehicle coordinators.

VPP/WSST Badge Lanyards

The VPP office and WSST members distributed badge lanyards to LANL workers. The lanyards are designed to securely hold multiple badges, keys, and dosimeters. They are completely nonmetallic, which is ideal for electrical workers and sensitive security systems. The lanyards are imprinted with the VPP slogan, Working Safely…TOGETHER, and the WSST slogan, Think Safety. Live Safely.

VPP Doormats

The VPP office purchased 48 indoor/outdoor doormats that facility managers placed at high-traffic entryways to reduce slippery floors caused by rain or snow.

Future VPP Safety Initiatives

The VPP office will continue to work with the WSSTs to determine future safety and security initiatives based on input from LANL workers. In addition, the VPP office will pursue the following four goals in order to further promote the VPP and WSST goals and objectives.

- Improve safety data analysis and trending to better predict injuries and illnesses so that they can be prevented.
- Strengthen working relationships between workers and managers.
- Continue communicating VPP goals, objectives, and benefits.
- Evaluate LANL's safety and health programs formally to identify opportunities to strengthen these programs.

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Backward Glance

Remembering the British Mission

This year marks the 51st anniversary of the Mutual Defense Agreement between the United States and the United Kingdom. Under this agreement, our 2 nations have worked closely to develop many of the innovative and reliable weapons that helped ensure the security of the free world for the past 5 decades. The origins of this productive nuclear partnership, however, can be traced back to World War II. In 1943, Britain supplied the Manhattan Project with several of her most talented nuclear scientists. Approximately 24 of these men came to Los Alamos, making valuable contributions to the development of the world's first nuclear bombs.

Initially, Nobel Laureate James Chadwick, discoverer of the neutron, led the British contingent at Los Alamos. The British Mission, as this group was collectively known, included prominent scientists such as William Penney, Geoffrey Taylor, Ernest Titterton, and James Tuck. Several European refugees, who fled Nazi persecution on the Continent, also joined the team. Included amongst them were the Austrian, Otto Frisch, the two Danes, Niels Bohr and his son Aage, and Joseph Rotblat, a Pole. Klaus Fuchs, an outstanding theoretical physicist and native of Germany, also came to Los Alamos as part of the British Mission. He played a prominent role in developing the implosion bomb, but repeatedly passed classified information to the Soviet Union. Rudolf Peierls, a fellow German theorist who recruited Fuchs, also came to Los Alamos and eventually succeeded Chadwick as leader of the British Mission.

Each member of the British Mission played a part in the success of the Manhattan Project. Many of the British scientists helped develop the implosion bomb, which was tested in July 1945 at Trinity Site in south-central New Mexico. Peierls and Fuchs helped spearhead research on the hydrodynamics of implosion and Tuck co-invented the high explosives lens system that would compress the bomb's fissile core. Taylor, an expert in blast wave phenomena, predicted how the bomb would behave during the test. Penney, who served on the committee tasked with selecting potential targets for the combat missions, developed diagnostic methods to measure blast force. Other British Mission scientists made contributions by serving as laboratory leaders. Frisch, Peierls, George Placzek (a Czech), and Egon Bretscher (a Swiss) all led groups during the war.

After the atomic strikes against Hiroshima and Nagasaki, the Japanese government quickly capitulated. The British scientists played key roles in building the bombs and, as such, became embedded in the social fabric of wartime Los Alamos. After Japan surrendered, the British wives threw a formal party to celebrate, preparing a traditional British meal of soup, steak and kidney pie, and trifle. After dinner, guests enjoyed a three-act play Tuck had written, which culminated in a reenactment of the Trinity test.

Not long after the war, Congress passed the Atomic Energy Act of 1946, which outlawed nuclear collaboration with foreign states. The atomic partnership that produced the world's first atomic bombs temporarily came to an end, and matters only worsened when Fuchs was arrested in Britain for espionage in 1950. Only 8 years later, the United States and United Kingdom would renew their nuclear ties by signing the Mutual Defense Agreement of 1958. British and American scientists still cooperate under the auspices of this agreement, and the collaborative spirit of the Manhattan Project continues to inspire their efforts. NWJ

Photos *(top to bottom)*: Otto Frisch at the piano; *clockwise*, Beatrice Langer, William Penney, Emil Konopinski, and Lawrence Langer in a Ford convertible; *left to right* Penney, Frisch, Rudolf Peierls, and John Cockroft.

Point of contact: Alan Carr, 505-664-0870, abcarr@lanl.gov

Badge photos *(left to right)*: Egon Bretscher, Otto Frisch, Klaus Fuchs, William Penney, Ernest Titterton, and James Tuck.

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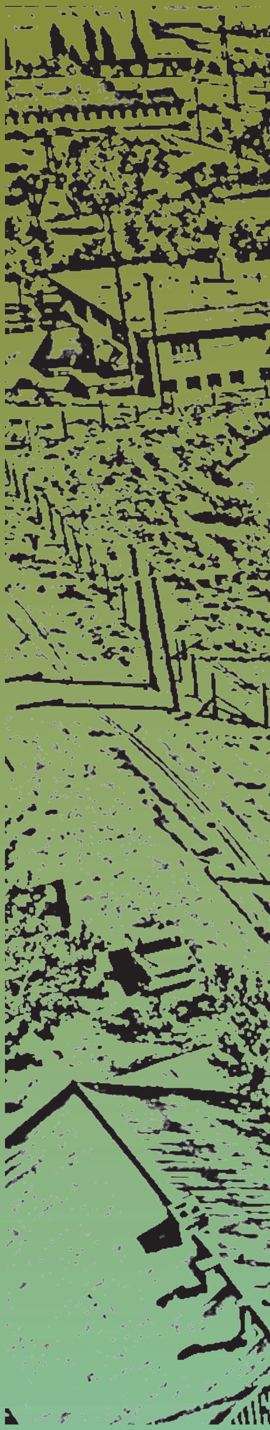

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