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Issue 1 2007

**Blast Waves at Sandia's Z Facility ♦ Fully Contained Tests at DARHT
Roadrunner Supercomputer ♦ Restoring V-Site ♦ Integrating Security
The Human Performance Philosophy ♦ LANL Builds War-Reserve Pit**

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About the cover: One of the five nuclear tests of Operation Ranger conducted at the new Nevada Proving Ground in January and February 1951. All five tests were dropped from the air and all were weapons-related tests.

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Point of View

Strategic Weapons in the 21st Century

Ambassador Linton Brooks

Opening Remarks, Lawrence Livermore and
Los Alamos National Laboratories Conference
January 25, 2007

Thank you! If you look at your program, you will note the word “former” before my name. Thus, I need to stress that I am speaking as a private citizen, although I think I would have said most of this last week when I was still a government official.

This is a conference on strategic weapons. The concept of nonnuclear strategic weapons is an important one, firmly supported by the Nuclear Posture Review (NPR) and worth a good deal of discussion. I am, however, going to confine my opening remarks almost entirely to nuclear weapons.

I want to start by suggesting some context for your discussions. We cannot intelligently decide where we are going without a clear understanding of where we are. Here’s where I think we are.

1. While the NPR was intellectually the most significant development in nuclear thinking since the Sloss Study of 30 years ago, we have never gone beyond the broad concepts to articulate what the New Triad means in practical terms. As a result, the NPR has been of limited value in presenting our story.

2. The Reliable Replacement Warhead (RRW) offers a number of benefits, and we should continue to support it strongly. By its very nature, however, it doesn’t do much for the subject of this conference. The argument for the RRW is that because we are going to have nuclear weapons for the foreseeable future, those weapons should be safe, secure, easy to manufacture and repair, and designed to increase the chance that we can continue to certify without returning to nuclear

testing. All of that is true, but it says nothing about the long-term political or military reasons to retain nuclear forces or about their necessary military capabilities.

3. We are increasingly hearing from thoughtful observers that political support for the RRW and the transformation of the Weapons Complex we are calling Complex 2030 will not be possible without greater consensus on the future role of nuclear weapons. Those taking this view call for a new national dialog on the purpose of nuclear weapons and the circumstances in which they are—and are not—relevant.



**Sooner or later nuclear forces,
policy, and doctrine will once
again play a commanding role in
our national security strategy.
Our task is to ensure that our
nation is ready for that day.**

4. This administration may not be able to foster or contribute to such a dialog. With my departure, there are few, if any, confirmed civilian officials who routinely speak on nuclear matters. Such a dialog must originate in the White House, but it is hard to see how the National Security Council (NSC) can focus on

nuclear issues in the final two years, when it will be increasingly focused—even more than in the past—on Iraq.

5. The current US strategy focuses on nonproliferation exclusively in terms of dealing with states

seeking to possess nuclear weapons while paying essentially no attention to any regime involving those that already have such weapons, which may be nearing the end of their utility. Those few members of Congress on both sides of the aisle who care about nuclear weapons are likely to continue to make a linkage between nonproliferation abroad and RRW and Complex 2030 at home. We are not ready for any real discussion of that linkage; our strategy thus far is to explain why it shouldn't exist. We may well be right intellectually, but it is not clear we will be able to sustain such an approach politically.

If this analysis is correct, this conference may need to aim at the next administration. Two years ago, many of us hoped that the first year of the second term would give us the opportunity to foster a national debate on nuclear issues. It is now clear that such a debate is unlikely to happen within the broader national security community. Only the relatively small groups of those who care about nuclear weapons, most of whom are in this room, are likely to engage in that debate. What we need, therefore, is a coherent set of options that might be available whenever the country is ready for that debate, including in the next administration.

This task would be hard enough, but any sustainable view of strategic weapons in the 21st century will have to overcome the series of myths, misperceptions, and predispositions that are floating around, including the following.

1. The misperception that the NPR, by including nonnuclear capabilities, lowered the nuclear threshold rather than, as it actually did, begin to substitute conventional and nonkinetic weapons for some previously nuclear missions.
2. The belief that the RRW is unnecessary because of plutonium aging, or because life extension programs and stockpile stewardship are working.
3. The belief that missile defenses won't work and, even if they did, would be destabilizing, especially with respect to China.
4. The strong, visceral reaction on Capitol Hill to anything that remotely suggests "new" nuclear weapons. This has resulted in the ludicrous situa-

tion whereby we must argue that RRW will utterly transform our approach to the stockpile and the Weapons Complex, but that there is nothing "new" about it.

With that as the backdrop, I want to give you my sense of some of the questions that it would be most useful for your discussions to elucidate. I'll organize them around the working groups into which you will be dividing.

In the area of international and domestic dynamics, I suggest that one major problem is the attitude of our international partners. Lew Dunn, Science Applications International Corporation, has recently done some analysis that suggests that most of the rest of the world thinks we are increasing our emphasis on nuclear weapons! As one who has spent much of the past five years trying to get anyone at all to pay attention to nuclear policy, I find this attitude stunning. But we need to recognize that it exists and that it has domestic implications as well.

This attitude is also related to an issue I mentioned earlier. Our approach to nonproliferation essentially ignores any role for limitations on existing states that possess nuclear weapons. Most of us in this room probably like such an approach, but I don't think it is sustainable in the long term. We need to figure out something better.

A third issue in the area of international and domestic dynamics is the need to figure out how we think about China. The dissuasion pillar of the NPR is usually assumed to be directed at China and to imply that we are not prepared to accept nuclear parity with China. In national missile defense we have never fully decided whether China is a big rogue to be deterred by denying it the capability for ballistic missile attack, or a small Russia to be deterred through the threat of devastating retaliation.

Finally, our domestic debate is dominated by misinformation. I suggested some examples earlier. If you want one recent illustration, see the January 15 *New York Times* editorial on the RRW. The title says it all: "Busywork for Nuclear Scientists." If we are to control the future of strategic weapons in the 21st century, we will have to find a way to have the

continued on page 23

Radiation-Driven BLAST WAVES at Sandia's Z Facility

The properties of radiation-driven blast waves are of increasing interest as scientists attempt to fully explain observations of stellar objects and events. Los Alamos National Laboratory has examined these phenomena as both a diagnostic technique and a code-validation tool.

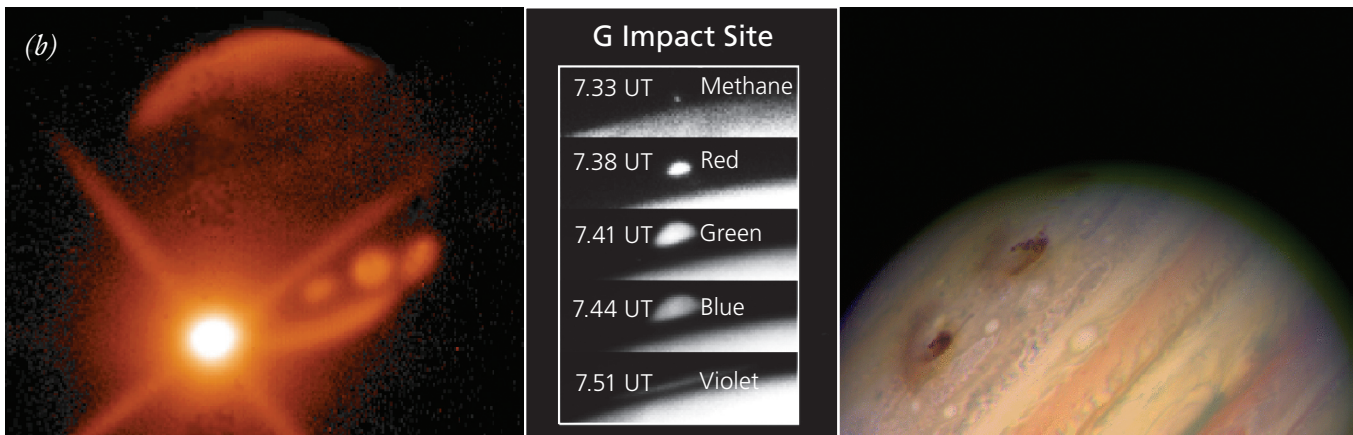
Blast Waves in Nature

Blast waves form when initially supersonic radiation waves expanding in a medium slow to near the hydrodynamic speed of sound. Such phenomena are commonly observed in astrophysics as novae and supernovae explosions or our Sun's coronal mass ejections. Here on Earth, blast waves have been observed with energetic releases from comet and meteor impacts.

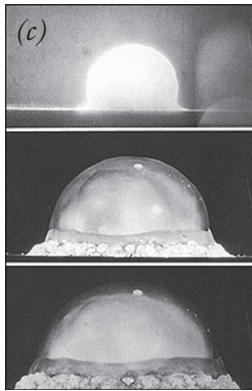
Supernova SN1987A and the recurrent nova RS Ophiuchi show characteristic signatures of blast waves. On February 23, 1987, astronomers observed the explosion of a massive star using the Hubble telescope. This cataclysmic event is called SN1987A, which released as much radiation as 100 million Suns. Its effects can still be seen 20 years later in the form of luminous blast waves. Similarly, the Rossi X-Ray Timing Explorer satellite recorded a strong radiation emission,



Blast waves and their effects. (a) A photograph from mineralogist Leonid Kulik's 1927 Soviet expedition to investigate the 1908 Tunguska event—suspected to be a comet or meteorite that exploded somewhere between 4 and 6 miles aboveground. Physical effects of the blast wave from the ~15 MT event are readily apparent throughout the area 19 years later.

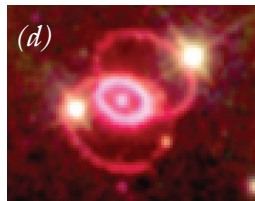


(b) Comet Shoemaker-Levy 9 was torn apart by tidal forces as it made its terminal approach to Jupiter. *Left*, the CASPIR near-infrared camera (MacGregor et al., Australian National University) records fragment "G" impacting the planet's atmosphere. *Center*, Dr. H. Hammel (MIT) used the Hubble Space Telescope to take five images of the resulting blast wave, which released an estimated 6 million megatons (6 TT) in equivalent energy. The five frames correspond to five color bands that allow astronomers to infer some of the chemical composition of the impact plume (UT stands for universal time). *Right*, the Hubble Space Telescope also recorded the aftereffects of fragment G's impact on Jupiter's atmosphere (dark spots in the upper latitudes).

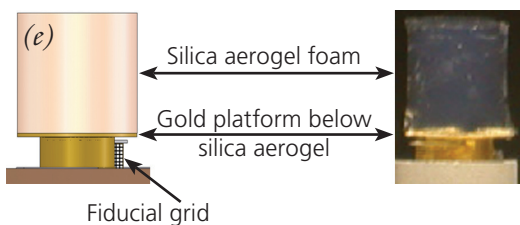


(c) The Trinity test's 18 kt detonation provided the first example of a man-made blast wave on a scale similar to those occurring in nature.

(d) One of the closest (astronomically speaking) supernovae ever recorded, SN 1987A (in the Large Magellanic Cloud



~168,000 light years away) provides astronomers with an excellent example of a naturally occurring blast wave from which we have been able to accurately measure the energy released—a key to understanding the physics of this astrophysical phenomena. The inner ring is the supernova's ejecta shocking the interstellar medium and surrounding gases. The two outer rings in an hourglass shape are the soon-to-stagnate blast waves. (Photo courtesy of NASA and the Hubble Space Telescope Institute)



(e) *Left*, an artist's rendering of the blast wave target. The aerogel foam is visible as a tan cylinder mounted on a gold platform. A fiducial grid, which provides researchers with a length scale in the experimental radiograph, is visible on the right-hand side of the target. *Right*, a photograph of one of the blast wave targets taken before being loaded in the Sandia Z-accelerator.

followed by an emitting mass accumulation some distance from the initial radiation source, RS Ophiuchi. Cataclysmic events, such as these novae, provide astronomers with insight into the makeup of interplanetary and interstellar material.

In 1908, a cataclysmic event occurred at Tunguska, Siberia, when an unknown object, believed to be a comet, exploded in the atmosphere. Analyses of the blast wave's inflicted damage upon ~830 square miles of Siberian forest led to an estimate of this event as equivalent to a 15 MT explosion. In comparison, the 1980 Mount St. Helens eruption was equivalent to ~7 MT in blast propagation. Accurate blast wave models are necessary to predict the destructive power of similar events.

A recent event in our solar system demonstrated the destructive power that a comet may have in the form of blast waves. In July 1994, comet Shoemaker-Levy 9 fragmented and impacted Jupiter's atmosphere. Recent estimates found that the impact of this comet's fragment "G" with Jupiter resulted in 6 million megatons (6 TT) of released energy.

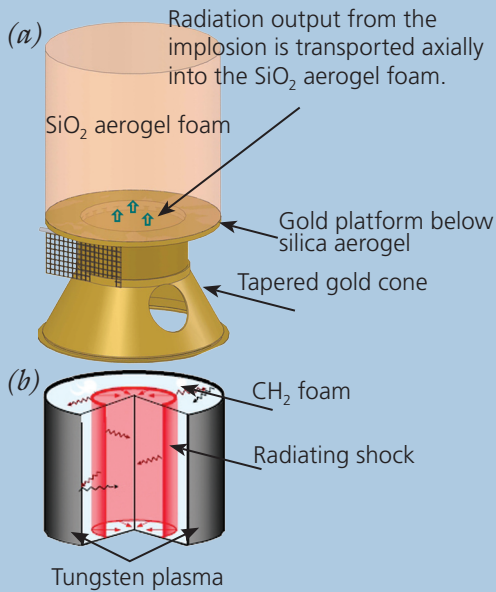
Adaptations of blast wave experiments are used to examine physics associated with radiation transport between the primary and secondary of a nuclear weapon.

Blast Waves in the Laboratory

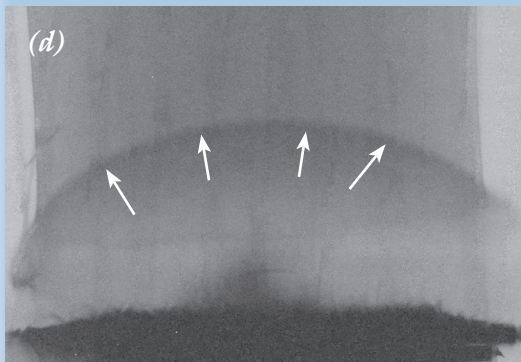
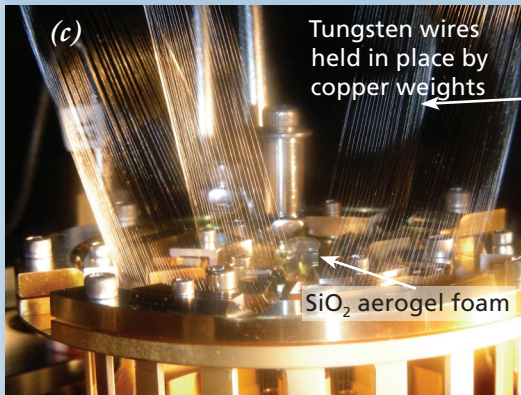
Blast waves have been observed on Earth with laboratory experiments and explosive detonations such as the July 1945 nuclear explosive Trinity test in Alamogordo, New Mexico. Blast waves are also found in laboratory experiments that use chemical or nuclear explosives or energetic, pulsed radiation sources such as those produced by laser or Z-pinch devices. A number of laboratory-scale experiments have studied blast waves at the Omega Laser Facility at the University of Rochester, the Helen Laser Facility at the Atomic Weapons Establishment in the UK, and at the Z Pulsed-Power Facility at Sandia National Laboratories in Albuquerque. Adaptations of blast wave experiments are used to examine physics associated with radiation transport between the primary and secondary.

LANL's Radiation-Driven Experiments

From 2004–2006, Los Alamos National Laboratory performed six blast wave experiments in collaboration with Sandia. The Z Facility offers a unique pulsed-power device that produces 2 MJ in x-rays from its 11.5 MJ of stored electrical energy. The axial

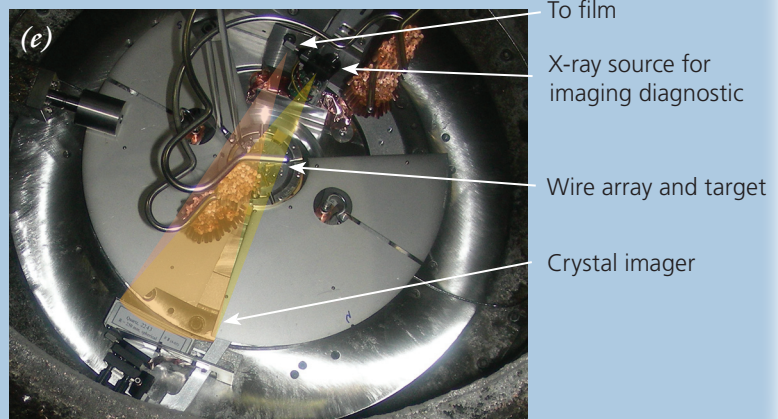


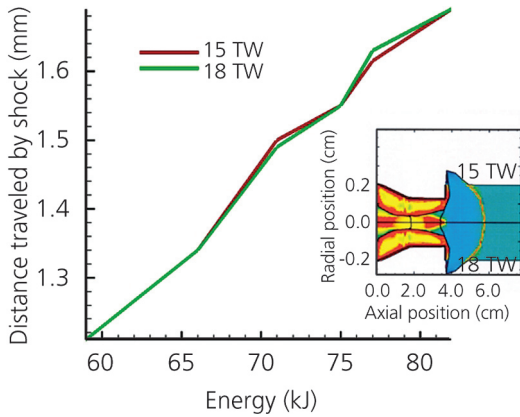
Imploding plasma, formed by vaporizing the tungsten wires, impacts the plastic foam.



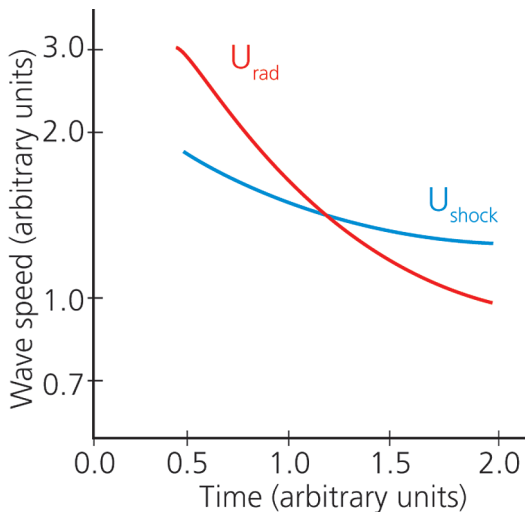
The blast wave is recorded using a diagnostic designed to image x-rays of a specific wavelength and energy level.

(a) Sandia's dynamic hohlraums are some of the world's most energetic and complex radiation sources. Los Alamos uses the axial emission of these sources. The blast wave targets consist of low-density silicon dioxide (SiO_2) aerogels resting on platforms made of gold, which are mounted on top of the dynamic hohlraum. (b) The dynamic hohlraums start with 4.5-mm-diam plastic (CH_2) cylinders surrounded by two cylindrical tungsten wire arrays, which are clearly visible in (c). The two annular wire arrays implode when Sandia's Z machine rapidly discharges its capacitor banks. Wires that have electrical currents in the same direction generate a magnetic field that causes the wires to attract one another by the Lorentz force. The large currents that pass through the wires cause the wires to vaporize, generating imploding plasma clouds. The tungsten plasma clouds converge as a cylinder, strike the plastic cylinder, and generate a radially converging shock. This shock emits quasi-blackbody radiation at near 2 million K, which has high intensities in UV and x-ray wavelengths. While the tungsten plasma continues to implode, some fraction of this radiation is confined—thus, the name "dynamic hohlraum." The radiation is free to escape out the top and bottom. LANL's experiments use the radiation that emerges from the top of this dynamic hohlraum. (d) Radiation comes up out of the dynamic hohlraum through the bottom of a gold cone and cylindrical section, and then out a 2.4-mm hole. After radiation emerges from the hole, it expands spherically into the aerogel as a diffusive radiation wave. The energy density of the radiation wave drops as it expands. Eventually, the wave slows to near the heated aerogel's speed of sound. This forms a blast wave at the radiation wave front, visible as a sharp density increase. We can take x-ray pictures of the blast wave because x-ray absorption increases with density. Using a laser-produced x-ray pulse, the blast wave's "shadow" is recorded—similar to this post-processed image. (e) The radiograph is captured by an imaging diagnostic composed of an x-ray source that shines its carefully timed "beam" through the target to a concave crystal mirror. Only x-rays of a specific wavelength are reflected to the film.





The blast wave is very energy sensitive, which is why it was used to estimate the amount of energy released during aboveground atomic testing. This plot shows results of simulated blast wave positions as a function of energy where two different radiation drive powers are used. Each curve shows blast wave positions from 6 simulations with time integrated drive energies ranging from 60–80 kJ at 15 and 18 TW powers. This plot shows that significant changes in source power, 20% here, result in similar blast wave propagation at identical time-integrated energies. The inset image shows simulated density plots at 10 ns after the start of the drive for the blast wave at the two powers.



Radiation wave speeds are energy sensitive and, thus, as the wave expands spherically, it drops in energy density and slows. The blast wave forms when the speed of an initially supersonic radiation wave slows to near the shock speed of the heated material. The energy sensitivity of the blast wave makes it a diagnostic for total integrated energy.

x-ray output, ~90–120 kJ, of this remarkably efficient x-ray source is used to drive physics experiments placed above the x-ray source.

The radially imploding Z-pinch starts with 360 7.5- μm -diam tungsten wires in two concentric arrays at radii of 1 and 2.5 cm. While imploding as a consequence of the Z accelerator’s electrical discharge, the wire arrays form a tungsten plasma shell almost 1-mm thick.

When this tungsten plasma shell impacts upon a cylindrical plastic foam, a radiating shock propagates inward to its axis. This implosion source is commonly referred to as a dynamic hohlraum. Some of the dynamic hohlraum’s pulsed radiation output is transported to the physics experiment placed on-axis above the foam. The radiation output is accompanied by a large x-ray background due to the high power associated with the electrical discharge.

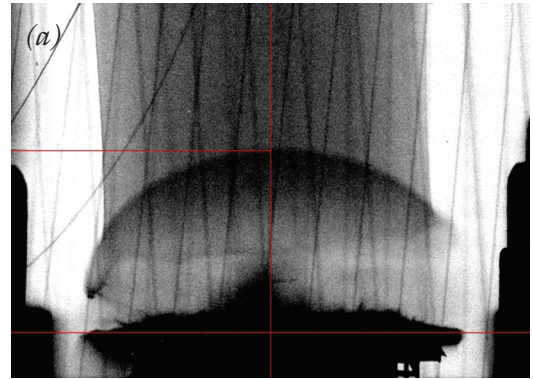
In LANL blast wave experiments, the axial radiation output of the dynamic hohlraum flows into a silicon dioxide (SiO_2) aerogel foam. The initially supersonic and diffusive radiation wave propagates through the foam as a Marshak wave, a decelerating thermal wave penetrating from a hot source into a colder medium.

The wave rapidly heats the SiO_2 aerogel foam as it moves and lowers the foam’s opacity behind the wave front. Because the wave is supersonic, the aerogel foam heats quasi-isochorically (i.e., very little change in density) and pressurizes too quickly to allow for significant material expansion.

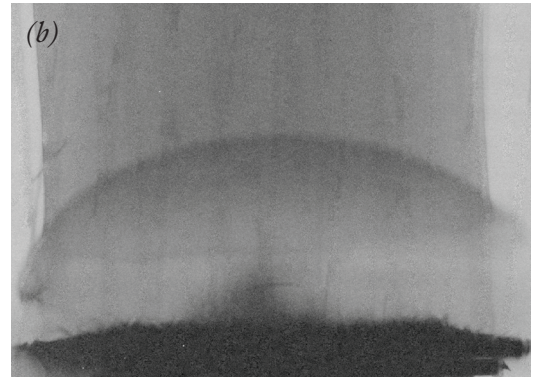
As the Marshak wave expands spherically, its energy-density drops and the wave speed slows to near the foam’s shock speed. At this point, the material responds hydrodynamically by building up a density perturbation at the position of the radiation wave front and forms a blast wave. This transonic blast wave is slower than the original supersonic Marshak wave.

The blast wave front is visible with x-ray imaging because the density perturbation increases x-ray absorption in the shock front. Over the past 5 years, Sandia has been developing a high-resolution x-ray imaging system that also reduces the x-ray background. Sandia uses the high-fluence Z Beamlet laser to rapidly heat pure metal foils, for example, manganese. The foils are rapidly heated to temperatures at which only a few electrons remain. The few (2–4) electrons that are still associated with the ions then have transitions that are hydrogen-like and helium-like. In the case of manganese, a significant number of the photons that are emitted as a result of electronic transitions have energies near 6 keV or wavelengths near 2 \AA .

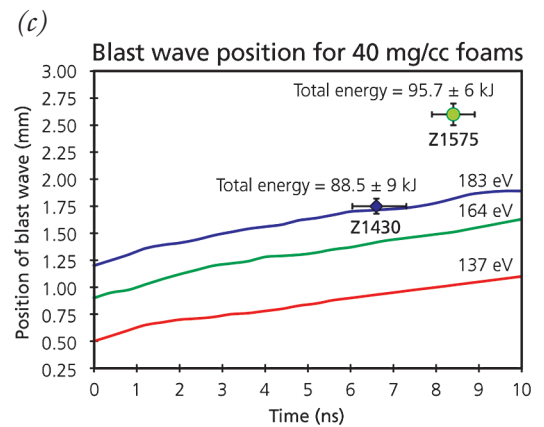
(a) The blast wave front is visible with x-ray imaging because the density perturbation increases x-ray absorption in the shock front. The white regions of the image are directly from the unattenuated x-ray source. The darker grey region is the 56 mg/cc silica aerogel foam that captures the radiation wave propagation. The blast wave appears as a shadow on the film where dark exposure regions correspond to more mass along the line-of-sight. The 7.5- μm -diam wires that hang above the dynamic hohlraum are visible as straight and bent lines in the image.



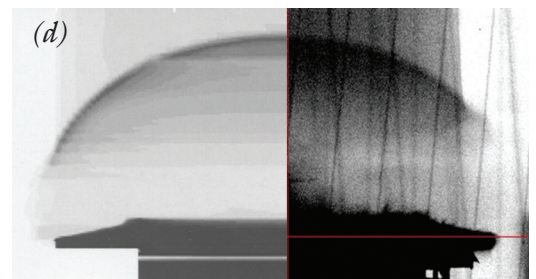
(b) Using digital image processing, the wire features are removed from the image. The blast wave is the curved “dome” that has formed above the dark cylindrical section. This “improved” image allows a computer code to perform automated fitting to the blast wave’s edges.



(c) The simulated blast wave positions are compared with the experimental measurements from Sandia shots Z1430 and Z1575. Initially, this comparison amounts to verifying the most forward position of the blast wave. Additional comparisons include examining the entire wave front shape, density profiles as measured by absorption, and ablation of the gold platform beneath the foam.



(d) The left side of the panel was produced from a simulated radiograph obtained by post-processing LASNEX simulations for the blast wave experiments. The right side of the panel is an x-ray radiograph of shot Z1632 on Sandia’s Z accelerator. The hemispherical blast wave is evident above the target in both images.



The x-ray imaging system uses a spherically bent (concave) quartz crystal with its 2243 axis oriented normal to the crystal surface. Like a spherical mirror, the crystal reflects and magnifies x-rays onto film. The unique feature of this imaging system is the way x-rays Bragg scatter from the crystal. Bragg scattering is produced when x-rays are scattered only at specific angles with constructive interference by the regularly spaced atoms of a crystal. In the case of the spherically bent crystal, the Bragg scattering occurs at near-normal incidence. By placing the crystal in a precise position relative to the x-ray source and film, only photons with x-ray energies of 6.151 keV or wavelengths of ~ 2 Å are imaged. This reduces the x-ray background from the Z-pinch and creates a high-resolution monochromatic image of the blast wave target.

The main advantage of using Sandia's Z Facility is that it provides the most useable x-ray energy available in nanosecond pulses at any high energy-density physics facility. Similar experiments are currently being performed at the Omega Laser Facility and will be performed at the National Ignition Facility.

We use the joint LANL-LLNL inertial-confinement fusion computer simulation code LASNEX to examine the sensitivity of the blast wave to computational and experimental uncertainties. Modeling shows that the position of the blast wave in the SiO₂ aerogel foam is a strong function of the input energy—as opposed to power and pulse shape. Therefore, in order to perform quantitative experiments that test physics models in our computer codes, the driving energy must be well diagnosed.

The computational model takes into account the emission of the radially converging shock in the plastic foam by treating the radiation output as the simulations' input source. The model transports this radiation into the SiO₂ aerogel foam and calculates the dynamic response using equation-of-state and opacity tables.

The blast wave is a good measurement technique for the transition from supersonic to transonic and subsonic radiation propagation. Furthermore, when the driving energy is well diagnosed, blast wave experiments can be a test of opacity and equation-of-state data. In the long term, these experiments will be used to help develop radiation transport models that could answer astrophysics, planetary science, and other physics questions. *[WWW]*

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DARHT Goes Green

Facility Conducts Fully Contained Hydrottest

Although the full-energy commissioning of the Dual-Axis Radiographic Hydrodynamic Test (DARHT) Facility's Axis-2 has lately taken center stage, the latest successful hydrottest, conducted at Axis-1, has temporarily stolen the spotlight.

The DARHT Facility successfully fired the first fully contained, high-explosive-driven experiment on May 15th. This hydrottest marks the beginning of fully contained hydrottests. Virtually all future testing at DARHT will be conducted inside large steel vessels, thereby eliminating nearly all environmental hazards.

"This hydrottest was the culmination of almost a decade of work, and required the dedicated efforts of a large cross-section of the Laboratory," said David Bowman of the DARHT Group. "Excellent teamwork by all involved resulted in a return of very high-quality data."

The experiment, number 3643, and called a dynamic core punch hydrottest, was the first to occur inside a steel containment vessel that confined the experiment's explosive byproducts. A core punch is LANL's name for a hydroshot that involves a nonfissile mockup of the weapon, which is then radio-

graphed to reveal information about the imploded cavity shape (i.e., the core of the weapon).

One of the major issues at DARHT is the time required between experiments due to cleanup at the firing point after hydrottests. With the move to fully contained experiments, program managers hope that the Laboratory will gain from a more environmentally responsible stance and also will be able to conduct more hydrottests in less time. Posttest sampling and monitoring confirmed that experiment 3643 was completely contained.

More important from a data-quality perspective, hydrottest 3643 also featured a new imaging system that includes a LANL-designed bucky grid camera, a remarkably engineered device that screens out scattered x-rays. Only x-rays coming directly from the experiment are allowed to pass to the imaging system. These direct x-rays form a radiographic image of the experiment at an instant in time. The net effect of the grid is to eliminate x-rays that would degrade the image; hence, a higher-quality image forms than had been available to date. Preliminary results indicate that this higher-quality image was achieved in hydrottest 3643 and that the new imaging system functioned as predicted.

Hydrottest 3643 was fired inside this large steel containment vessel at DARHT on May 15th. Before the experiment, the vessel was placed at the firing point inside a plywood structure designed as a backup environmental barrier. *Inset photo:* Peering inside the containment vessel gives a perspective on its massive size and its 2-in.-thick steel walls.





This photo shows the aftermath of hydrotest 3624, which used foam as a material to mitigate the release of materials to the environment. In addition to the products of detonation, an open-air hydrotest results in a waste stream composed of metal, plastic, and concrete.

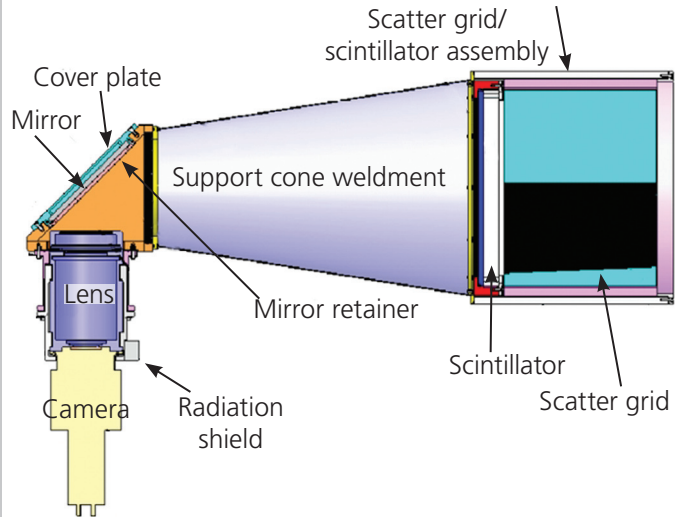
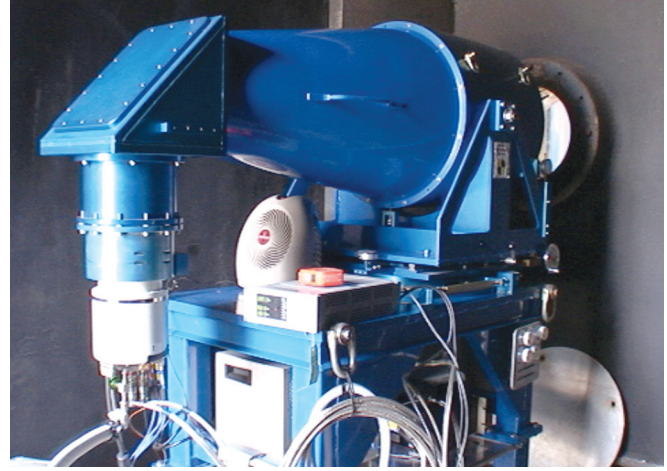
Hydrodynamic tests produce radiographs and other data from implosions of mock nuclear weapons components. Quantitative information is extracted from the dynamic radiograph and compared with hydrocode predictions in areas that interest weapons designers. A sophisticated modeling tool, a LANL computer code called the Bayesian Inference Engine, is used to extract data and compare radiographs with hydrocode predictions. Comparing data with code predictions gives LANL a means to enhance the predictive capability of hydrocode models.

Hydrotest 3643 was the first event in a two-shot series. A number of factors drove the choice of DARHT as the site for this experiment, including the relatively high x-ray dose at DARHT, the small DARHT spot size, and the DARHT gamma-ray camera system. Another factor is that DARHT is a highly reproducible radiographic machine, which means that once the machine is tuned, parameters such as dose and spot size do not vary significantly with time.

Hydrotest 3643 involved DARHT's highly reliable Axis-1, an electron beam accelerator used to create a single pulse of high-energy x-rays. Axis-2 is undergoing full-energy commissioning in the summer of 2007. It is designed to produce a four-pulse beam of x-rays at a 90° angle from Axis-1, allowing scientists to capture short movies of experimental implosions and to create three-dimensional images. **NWJ**

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Hydrotest 3643 included the first use of a bucky grid camera that screens out scattered x-rays and allows only x-rays coming directly from the experiment to pass to the imaging system. The new camera system performed exceptionally well and produced excellent data, according to the test leader.

Small Spot Size

DARHT produces x-rays by interaction of the electron beam with a thick target. Although we do our best to focus the electron beam before hitting the target, the source of the x-radiation (the interaction of the electron beam with the target) is never a true point source. This results in blur (or unsharpness) in the image that is attributable to the finite source size (or spot). Minimizing the spot size helps to minimize the overall system blur.

The system has other sources of blur, for example, motion blur.

LANL's Roadrunner HPC System



Los Alamos National Laboratory, in partnership with IBM, is developing and deploying the Roadrunner High-Performance Computing (HPC) system. High Performance Computing; Computer, Computational, and Statistical Sciences; Computing, Telecommunications, and Networking; Applied Physics; and Theoretical Divisions are involved in developing the Roadrunner supercomputer.

LANL's primary goals for the Roadrunner system are to

- provide a large capacity-mode computing resource for weapons simulations,
- implement an option for a petascale, hybrid accelerated architecture capable of supporting LANL's future workload, and
- lead an industry-wide technological revolution in HPC.

The Roadrunner Project will be implemented in three phases. Phase 1 system delivery is complete. LANL acquired, installed, and deployed more than 81 teraFLOPS of a base system to provide capacity computing cycles in the near future. Phase 2 includes a technology refresh with improved prototype hardware/software with cell blades and cell software to support the phase 3 final system assessment. Phase 3 includes the optional procurement and installation of a hybrid architecture computing system to provide a petascale resource for the weapons program. This hybrid

architecture consists of over 3000 integrated hybrid nodes that include Advanced Micro Devices (AMD) Opteron processors with cell blades.

Roadrunner Base System—On Track to Deliver Computational Cycles for Stockpile Stewardship

The Roadrunner base system was delivered in September 2006. LANL and IBM completed acceptance testing of the base system in December 2006.

Roadrunner's base system has 14 connected units (~71 teraFLOPS) for classified computing and 2 connected units (~10 teraFLOPS) for unclassified computing. Each connected unit consists of 144 Opteron X64 processors from AMD connected with a high-speed InfiniBand 4X interconnect fabric. In the unclassified computing environment, the system



The Roadrunner base system has been installed at LANL. This Linux-based supercomputer is named after the speedy state bird of New Mexico.

also includes initial test beds of the Cell Broadband Engine, predecessor of the enhanced Double Precision (eDP) computer chip to be used in the Roadrunner final system. These test beds are being used for initial work on applications software and systems software to prepare for the optional hybrid system in phase 3.

Since LANL and IBM completed acceptance testing, the system has been undergoing focused

system integration for assimilation into LANL's classified computing environment and initial applications testing. System integration includes infrastructure planning, deploying key network and input/output (I/O) capabilities to accommodate Roadrunner in the Strategic Computing Complex, and installing and testing the production

software stack (e.g., compilers, debuggers, message-passing interface, I/O libraries) required by applications. System monitoring and performance tools and processes for tracking system reliability and usage statistics are also being integrated.

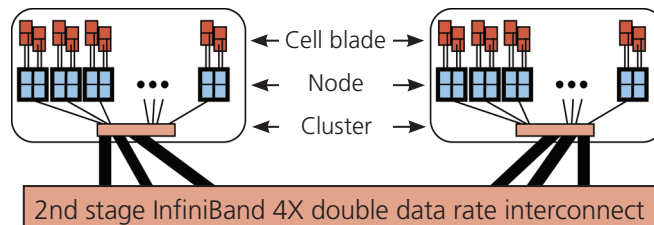
Following security accreditation in May 2007, the system is operational in the classified computing environment. Several key weapons applications are running on the base system, meeting a Level 2 advanced simulation and computing milestone in June 2007. The system is scheduled to transition to targeted production at the end of August. Roadrunner will more than double LANL's enduring capacity computing available for nuclear weapons applications that involve engineering, science, and certification.

Hybrid Computing Architecture—A New Era in Scientific Simulation

Phase 2 is planning and assessing the hybrid architecture system targeted for deployment in phase 3. The advanced hybrid architecture system will contain both Opteron processors and the eDP processing elements.

Los Alamos and IBM have improved the Roadrunner system in two major ways. First, communication performance has improved by a factor of 4, both in the cluster system interconnect and within the hybrid nodes. The final classified system, planned for 2008, will have Opteron and IBM cell blades directly connected for sustained petaFLOPS performance. Second, there will be no operational impact on the base system because IBM will deliver an entirely separate final system.

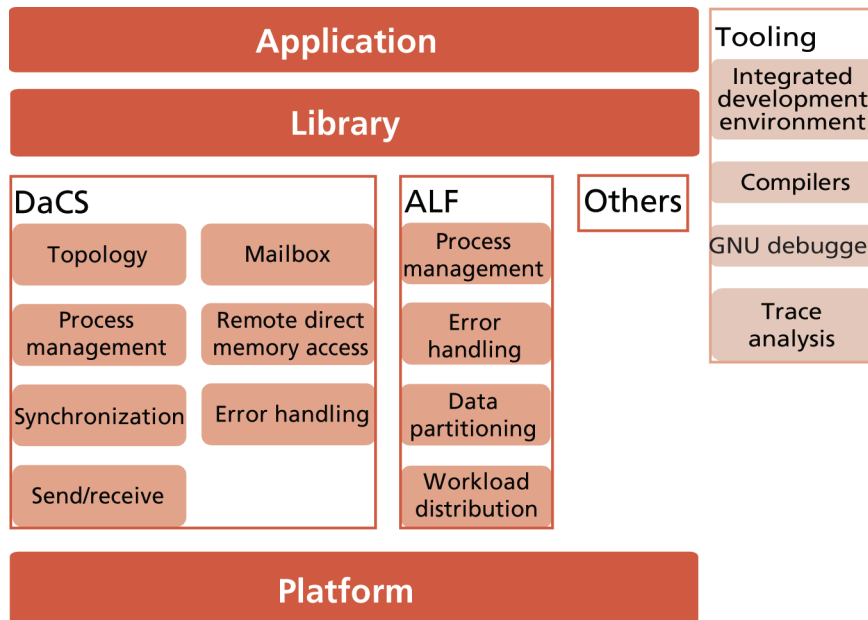
The flow of data within both the hybrid node and the eDP chip is an essential element of the programming strategy for Roadrunner. To this end, Los Alamos and IBM are jointly developing a hybrid system programming model that will be used first in Roadrunner and will also provide an effective application programmers interface (API) for future hybrid systems. Feeding



The Roadrunner hybrid architecture with cell blade accelerators.

the voracious appetites of the floating-point units will become the foremost concern for the future HPC programmer. The Data Communication and Synchronization Library (DaCS) and Accelerator Library Framework (ALF) are flexibly designed to address issues for a variety of architectures. Thus, the final hybrid system will be the first, full-scale example of the future of high-end computing. **NW**

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The DaCS and the ALF are the core of Roadrunner's API. More broadly, cells, graphics processing units, field-programmable gate arrays, and many-core chips represent a technological revolution in HPC.

Restoring V-Site— Birthplace of the *Gadget*

V-Site is located deep inside the current high explosives (HE) research and development area at Los Alamos National Laboratory. This site is significant because the activities that took place in six wooden sheds and the events leading up to those activities transformed the world and ushered in the Atomic Age. The buildings of V-Site are among the most historically significant buildings of the 20th century.

V-Site buildings were typical of World War II temporary wood structures at military installations. The buildings were wood post-and-frame construction that rested on concrete slab floors. Asbestos shingles covered the exterior. Earthen berms, which served as protection against HE accidents, surrounded the buildings and were secured by heavy wood post-and-beam retaining walls.

The Manhattan Project

The Manhattan Project (1942–1946) consisted of two major efforts: production of fissile material and the research, design, and production of a new class of weapon that could end World War II. Manhattan Project installations at Oak Ridge, Tennessee, and Hanford, Washington, focused on production of enriched uranium and plutonium that could be used with new weapons designed at Los Alamos.

Los Alamos, known as Project Y during the Manhattan Project, was the location of the secret research and development efforts to design and build the first atomic weapons. Project Y brought together physicists, engineers, and the Special Engineering Detachment of the US Army to design and build the weapons.

The initial plans called for a gun-type design employing Oak Ridge's enriched uranium and Hanford's plutonium. The gun design was concep-

tually simple and involved shooting one subcritical mass of fissile material into another subcritical mass. The two subcritical masses would form a critical mass, thereby releasing a tremendous amount of nuclear energy.

An early alternative to the gun design was the implosion method. The implosion method, a technically efficient approach, was intended to be a backup to the gun design. In 1943, J. Robert Oppenheimer, the Laboratory's first director, allowed a small number of scientists to pursue the implosion method.

In 1944, Los Alamos scientists determined that the gun design was not suitable for use with plutonium. The main reason was that plutonium produced in nuclear reactors, such as the plutonium produced at



Fat Man assembly at V-Site.



November 1946 aerial view of V-Site (dark buildings in foreground).



Aerial view of V-Site after the Cerro Grande Fire (building 516 is marked by an arrow).

Hanford, contained an isotope (plutonium-240) that released neutrons. Unfortunately, the high neutron background required assembly speeds that could not be attained using the gun design. Assembly speed is the speed at which two subcritical masses of fissile material are joined. If the speed is too slow in comparison with the spontaneous fission rate of the material being used, the weapon will predetonate. This means that the weapon would blow apart before enough generations of fission occurred to produce an efficient, high-yield explosion.

The realization that plutonium could not be used in the gun device caused a major reorganization of the Laboratory in August 1944. At this time, two new divisions were set up to develop the nuclear and HE components of the implosion device—G Division for gadget (the nickname for the plutonium implosion test device) and X Division for explosives.

Fortunately, development of the gun weapon was well under way. The Laboratory mobilized its limited resources and accelerated research on implosion in hopes of developing a plutonium weapon that could be used in addition to the uranium gun device. Scientists were less confident about the implosion design, which used precisely shaped HE charges to compress a subcritical mass of plutonium-239. The symmetrical compression increases the density of the fissionable material and causes a critical reaction.

V-Site

Despite the myriad diagnostic techniques used, uncertainties surrounding the implosion design necessitated a test. Alamogordo Bombing Range in south-central New Mexico was selected as the test site—code named Trinity Site.

The Army Corps of Engineers constructed V-Site as a new facility for the final assembly of the Trinity test.

The site consisted of six buildings. The first building, built in early 1944, was a small triangular-shaped shop with an earthen berm and used for explosives work before two high-bay buildings, two radiography buildings, and a covered storage area were constructed in late 1944. One of the high-bay buildings, building 516, and the radiography buildings were surrounded by earthen berms as a precaution against HE accidents. A no-peek fence surrounded the area.

During the week of July 9, 1945, the gadget was assembled in building 516. The shaped pieces of HE were fitted together and readied for transport on a flatbed truck to Trinity Site for the test. At Trinity Site, the HE was assembled with the plutonium core. On July 16, 1945, the US successfully detonated the world's first atomic device.

The weaponized version of the implosion device, Fat Man, received diagnostic testing at V-Site, including testing the components to ensure that they could withstand cold temperatures and vibration.

Little Boy, the untested uranium gun weapon, exploded over Hiroshima, Japan, on August 6, 1945. Fat Man exploded over Nagasaki three days later on August 9.

After World War II, V-Site was used for HE work until it was abandoned in place in 1960. The six buildings stood empty until the Cerro Grande Fire, which burned 42,000 acres of the Pajarito Plateau in May 2000, destroyed four of the six buildings. Fortunately, the fire spared the most significant building, 516, where the Trinity test device (the gadget) was assembled.

Restoration of V-Site

In 1999, the DOE committed to restore V-Site, acknowledging it as one of the most significant historic building sites in the DOE Complex. A Save America's



V-Site assembly building (516) before restoration.



Phase 1 reconstruction of the earthen berm and berm retaining wall.



Reconstructed earthen berm and retaining wall.



Phase 2 reconstruction of the assembly building roof (note reconstructed retaining wall at rear of building).



Buildings 516 and 517 at V-Site restored to their original 1944 condition.

Treasures grant was awarded to the DOE for the restoration project. This public-private partnership grant required the DOE to match the federal grant with private funds before the restoration project could begin.

In addition to the DOE's preservation efforts, the New Mexico Historic Preservation Alliance determined that the Manhattan Project buildings at Los Alamos were among the state's most at-risk historic properties. Recognizing the significance of the Manhattan Project, the DOE, in cooperation with the Advisory Council on Historic Preservation, designated seven properties across the DOE Complex as signature facilities of the Manhattan Project, including V-Site.

From 2000 to 2004, the National Trust for Historic Preservation and the Atomic Heritage Foundation raised the matching funds that released the federal funds to restore the two V-Site buildings that were not burned in the Cerro Grande Fire.

Plans for restoration were developed from the original 1944 as-built drawings. Phases 1 and 2 addressed structural deterioration and phase 3 addressed cosmetic restoration. Restoration work began in December 2005.

Phase 1 involved removal and restoration of the earthen berms, reconstruction of the massive berm retaining walls, and installation of a modern french drain and moisture barrier system. It was clear from V-Site's deteriorated condition that water damage from failing roofs and poor drainage caused the major structural failures.

In phase 2, a construction contractor reconstructed roofs and gutters and redirected water flow to a system of drains that moved precipitation off the buildings and away from the berms. The contractor restored the west wall of the assembly building and rebuilt a number of sill plates and wall footings.

In phase 3, the contractor rebuilt doors and restored wood trim to its original olive green color. A suitable substitute for the asbestos exterior shingles replaced broken exterior shingles. Finally, the large gates that originally hung at the entryway to V-Site were recreated from the original timbers in the 1944 berm retaining walls. The 60-year-old timbers were remilled and the gates were built using the original as-built drawings from the Laboratory's engineering archives. The project was completed in June 2006.

Reconstruction of V-Site represents an important milestone in preserving the nation's most significant historic buildings. Assembly of the gadget and the test at Trinity Site changed the world. **NW**

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Preventing Serious Accidents with the Human Performance Philosophy

Human performance as a facet of organizational structure comes from the Institute for Nuclear Power Operations (INPO)—a consortium of America’s nuclear power production facilities that studied safety performance and worker behavior at its facilities for 15 years.

As a result of its study, INPO developed a program to improve safety, performance, and efficiency and devised the following set of key human performance principles.

1. People are fallible—even the best workers make mistakes.
2. Error-likely situations are predictable, manageable, and preventable.
3. Individual behavior is influenced by organizational processes and values.
4. People achieve high levels of performance based largely on the encouragement and reinforcement received from leaders, peers, and subordinates.
5. Understanding the reasons why mistakes occur and applying lessons learned from past events can prevent accidents.

The Accident Pyramid

H. W. Heinrich’s accident pyramid illustrates a commonly held belief that safety conforms to the law of averages and leads one to conclude that minimizing the number of no-injury accidents will reduce the probability of more severe accidents. The underlying assumption of Heinrich’s theory is based on probability. Therefore, the number of accidents is inversely proportional to the severity of those accidents.

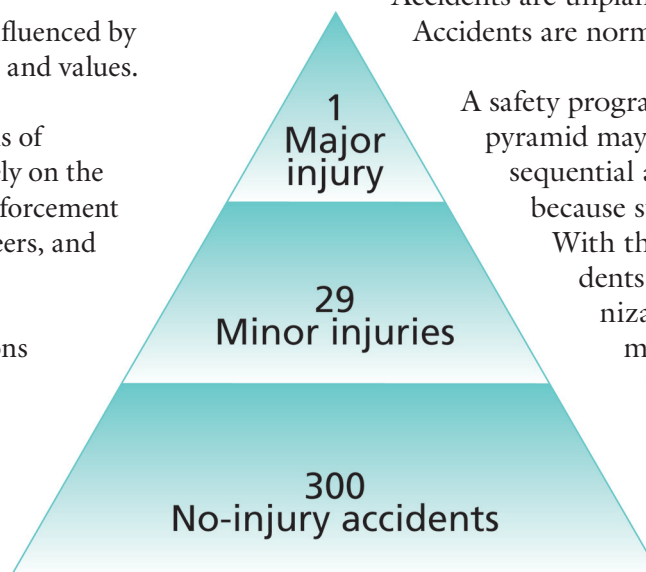
Heinrich did not provide empirical data to support his pyramid. He simply used a commonly held notion—some day our unsafe behavior will catch up to us.

Reevaluating the Meaning of Inconsequential Accidents

Accidents are unplanned, unintentional events.
Accidents are normal.

A safety program that follows Heinrich’s pyramid may drive reporting of inconsequential accidents underground because such a program is punitive. With the belief that little accidents lead to big accidents, organizations strive to eliminate all mistakes by punishing those who make them. Instead of eliminating mistakes, these efforts merely teach us not to talk about our

In reality, near misses are probably the best data that we receive on the reliability of safety systems.



Developed in 1931, Heinrich’s accident pyramid applies the law of averages to safety. Generally accepted for approximately 70 years, the pyramid illustrates Heinrich’s theory of accident cause: unsafe acts lead to minor injuries and, over time, to major injury. The accident pyramid proposes that for every 300 unsafe acts (no-injury accidents) there are 29 minor injuries and 1 major injury.

mistakes. It is futile to try to punish accidents out of any system.

A New Perspective on Inconsequential Errors

In reality, near misses are probably the best data that we receive on the reliability of safety systems. Accidents without consequence are a good thing. They tell us that our safety systems are working and show us precisely where we need to reinforce our systems against human error; in other words, never move a barrier that has dents in it. We don't get that type of actionable information from commonly used lagging indicators such as total recordable case and days away, restricted, or transferred rates, which essentially tabulate numbers for the accident pyramid.

A Change in Focus from Errors to Defenses

Contrary to Heinrich's law of averages, any mistake can lead to a severe injury or other disastrous consequence. Hazard assessments reveal that the severity of accidents is relative to the risk and severity of the hazards involved in the activity and not how often that activity is performed.

What keeps people from getting hurt isn't reducing the number of mistakes. On the contrary, it is increasing the number of defenses against the consequences of mistakes. Defenses are the protections we build into our work based upon recognized hazards and risk assessment. Rumble strips, an example of a robust defense, along the highway do not stop the driver from making an error. Rumble strips do allow the driver to realize that he has made a mistake and that he now has the ability to control the consequence of this mistake. The driver can continue to pull off the road, can correct for the error, or can crash the car.

Knowing what defenses to build and where to place them makes us recognize that mistakes are predictable and preventable and that we can keep mistakes from becoming significant accidents. We know this because we make inconsequential mistakes all the time and we can predict what the consequences might have been under different circumstances. Therefore, near misses aren't omens of doom; they are essential to building and maintaining defenses against mistakes. In other words, they help us put the right defenses in the right places.

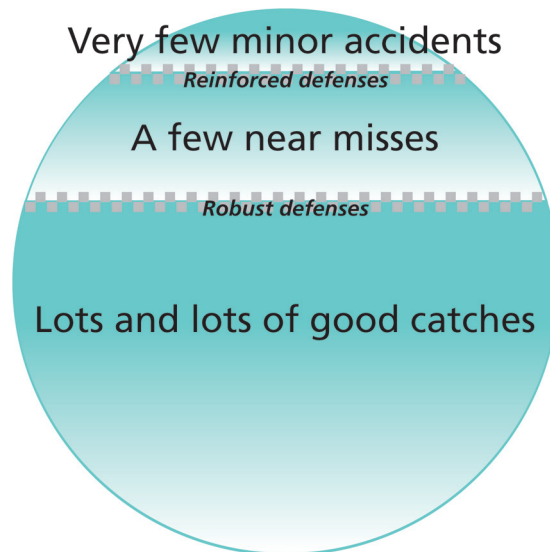
Learning from the Accidents Sphere

A new perspective on accidents, consequences, and defenses challenges us to revisit Heinrich's theory. The accidents sphere doesn't illustrate the law of averages. It shows us what data we should seek in order to effectively build and maintain defenses within a safety system.

The sphere shows that we must discover as many mistakes and near misses as we can to fully understand the conditions that our safety systems must overcome. Quite the opposite of trying to drive these base numbers down, we must find new ways to identify, investigate, track, and trend mistakes and near misses.

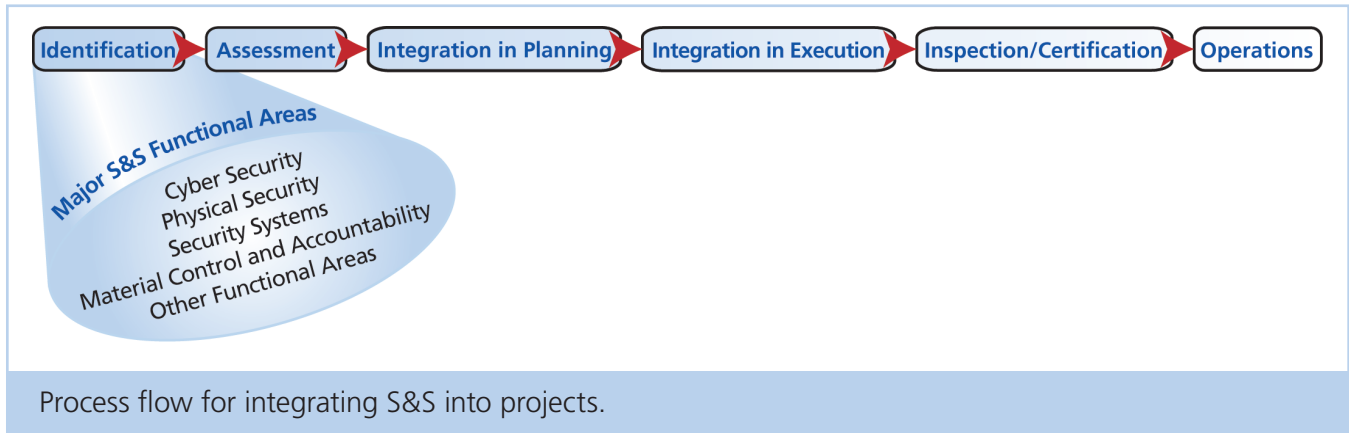
The next time you or a colleague makes a mistake, don't curse under your breath or ask how could you be so stupid? Appreciate what kept the mistake from becoming an accident, consider if that defense is robust and reliable, and learn how the mistake can help you better understand the safety systems that you work within. **NWJ**

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The accidents sphere reframes the accident pyramid to show that we must seek out information about close calls, near misses, and minor accidents in order to build and reinforce barriers against the consequences of inevitable human error. Robust defenses are layered and diverse, for example, administrative and engineering controls. Reinforced defenses, a higher level of defense than robust defenses, are both redundant and robust.

Integrating Security with Projects and Mission Changes



LANL's Safeguards and Security (S&S) Requirements Integration Team (RIT) promotes Integrated Safeguards and Security Management (ISSM) by incorporating S&S planning into construction, facility modifications, facility upgrades, decommissioning, demolition, operational projects, or mission changes that impact LANL operations. Since its inception in 2001, the S&S RIT has applied ISSM to more than 600 LANL projects.

The S&S RIT identifies and addresses security interests that must be included in project planning and project execution. Security interests include Laboratory-controlled classified and sensitive unclassified matter, nuclear materials, critical mission assets, select biological agents and toxins, and other government resources associated with accomplishing the Laboratory's mission.

The S&S RIT ensures that appropriate S&S subject matter experts (SMEs) engage project managers and the organization that controls the project, or the responsible project authority, in designing, developing, and implementing cost-effective and sustainable security controls.

Process

The S&S RIT identifies security SMEs for each major functional area usually present in a project: cyber security, physical security, material control and accountability, the protective force, and security systems. From that point forward, the security SME helps to resolve security issues and to support project managers in applying ISSM principles to their activities.

The project template for S&S deliverables follows the general project management process used at the Laboratory.

The S&S RIT is connected to a major computer network that provides current information on project and mission change activities throughout the Laboratory. The team also employs informal networks and methods to gather project information, attends monthly LANL/DOE Los Alamos Site Office project reviews, develops the security input to the Ten-Year Comprehensive Site Plan, and works with institutional planning committees.

For each major project, the S&S RIT creates and maintains a project file in a centralized database.

Each file is updated throughout the life of the project. Project files may include preliminary S&S questionnaires, which can be used to collect security requirements information from project personnel. Where applicable, accumulated data from projects is used to develop Laboratory S&S standards.

The S&S RIT meets weekly to evaluate new and ongoing activities. Activities are evaluated on the basis of security importance and complexity. A security representative is then assigned to each project.

The S&S RIT uses three graded levels of S&S importance and complexity: low, medium, and high.

Projects with low-level S&S assets receive basic communications from the S&S RIT and an S&S point of contact. For these projects, security representatives (security program lead or division security officer) deployed to the organization that controls the project handle most of the coordination and resolution of security issues.

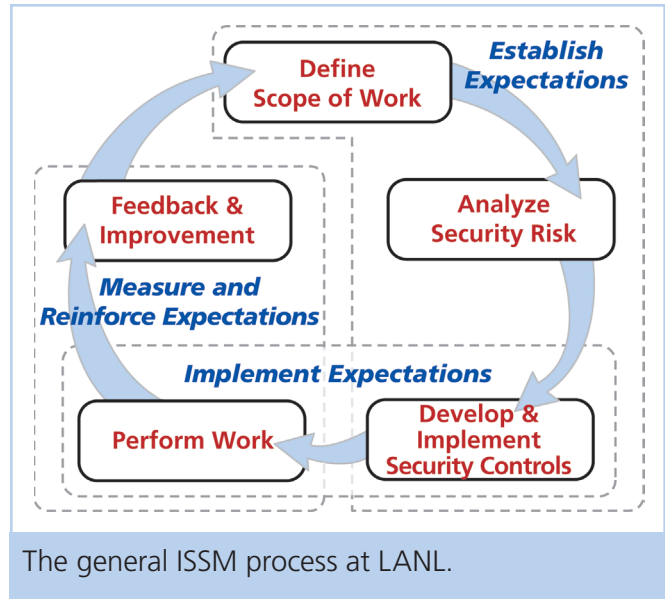
Projects with medium- or high-level S&S assets usually require an S&S team that includes an S&S RIT representative and several security SMEs. Security program managers designate SMEs from their departments or groups. The S&S RIT creates and coordinates security SME teams that provide expert input at appropriate project junctures.

The S&S team provides support throughout the project to ensure effective security integration and participates in the project until the project is turned over to operations. At that time, the S&S team is dissolved.

Benefits of the S&S RIT Process

Integrating S&S in the project planning stage has helped eliminate rework and costly retrofits that were sometimes necessary because security needs were not recognized until a project was under way.

Including realistic security-related needs in project baselines has reduced unplanned scope, schedule, and cost impacts. Additionally, more consistent S&S delivery improved poor customer percep-



tions of S&S that resulted from unfulfilled obligations, inconsistent products, and inconsistent policy implementation.

Integrating the S&S RIT at the start of project planning enhances efficiencies at the institutional level by standardizing S&S approaches and identifying risks on a broader level.

The S&S RIT approach also provides Laboratory-wide perspectives on security needs and controls, allowing S&S staff to identify interdependencies among projects and functions. For example, several major projects are concurrently modifying Technical Area (TA) 55, all contained within a relatively small geographical space. This creates a high number of interdependencies from a logistical standpoint.

Any change to a facility as important as TA-55 must be reviewed by security, using sophisticated methods. Any change to any facility space configuration or function requires an adjustment to compensate for the corresponding change to the security envelope. Presently, many of these changes are occurring to the TA-55 security envelope.

Integrating S&S in the project planning stage has helped eliminate rework and costly retrofits.

This systematic approach to S&S integration has improved the Laboratory's ability to plan and manage security vulnerability analysis (VA) work conducted for projects. The Site Safeguards and Security Plan Team conducts this work. Thus, S&S staff is better able to proactively identify and negotiate deliverables such as VA reports for projects.

Based on its experience, the S&S RIT provides input to institutional site planning and project management procedures. The S&S RIT has also undertaken process improvement efforts, including providing clearer guidance to project managers.

Process Development Problems

When the S&S RIT was first organized and developed, it was a challenge to ensure that the S&S RIT was notified of projects as they were being initiated.

For example, when a parking structure was planned next to a nuclear facility, security consid-

erations were not raised until the project required approval from LANL's Infrastructure and Facilities Committee. Cost and schedule impacts would have been substantially reduced if initial project discussions had included security considerations. Eventually, the parking structure project was canceled in order to conform to site protection strategies.

Success of the S&S RIT

The S&S RIT has developed a systematic method that ensures S&S requirements are addressed at various stages in project activities. The process has helped standardize security input and ensure timely, project-specific security input. As a result, the Laboratory has reduced the number of unplanned S&S impacts to projects, applied more standardized S&S approaches, and used limited S&S human resources more efficiently. **WWW**

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LANL Produces War-Reserve Pits

Senator Pete Domenici, General James Cartwright, and Representative Heather Wilson assembled at LANL's Technical Area (TA) 55 Plutonium Facility on July 2, 2007, to celebrate the first diamond-stamped pit produced by Los Alamos. Steve Henry, Deputy Assistant to the Secretary of Defense, and Dan Glenn, Los Alamos Site Office Manager, were also present for the celebration.

While Senator Domenici, General Cartwright, Mr. Henry, and Mr. Glenn looked on, NNSA quality assurance officials diamond stamped a second W88 pit, accepting it for inclusion in the nation's nuclear stockpile. Stamping a diamond-shaped mark on the pit often denotes war-reserve (WR) quality. The diamond stamp signifies that the product has been built to the strictest rigor and to the highest quality standards required by the DOE and DoD.

After touring the Plutonium Facility and watching the second pit receive a diamond stamp, the dignitaries joined Director Michael Anasasio and Principal Associate Director Glenn Mara in the TA-55 auditorium to congratulate employees who participated in the W88 Pit Manufacturing and Pit Certification Programs.

To ensure that LANL-manufactured pits met the same high standards as Rocky Flats-built pits, a series of nine "development" pits were manufactured and exhaustively tested (1998–2002).

In 2003, LANL produced the first pit built with approved processes (QUAL 1). Since delivering the QUAL 1 pit, LANL scientists and engineers have worked to demonstrate the functionality and equivalency of a Los Alamos-built pit compared with a Rocky Flats-built pit.

LANL's ability to certify its pits for use in the stockpile relied on a variety of skills from across the Laboratory and the Nuclear Weapons Complex, including radiography at Lawrence Livermore National Laboratory. Fabricating a pit includes casting; performing chemical or radiographic analyses; machining; and inspecting, joining, and assembling components.

Producing the first LANL-built, WR-quality pit is a notable accomplishment for the Stockpile Stewardship Program that drew on the broad scientific, engineering, and management skills unique to the Laboratory. This accomplishment is even more

exceptional because this is the first pit to be manufactured without an underground test to determine its viability.

LANL received its first diamond stamp in June 2007. This diamond-stamped pit was delivered to the Pantex Plant in Texas for assembly into a W88 warhead, which, when certified, will be delivered to the US Navy.

Los Alamos-built WR pits will replace pits that have been or will be destructively analyzed as part of the Surveillance Program of the W88

warhead. These analyses ensure the continued safety, security, and reliability of this key element of the nation's nuclear deterrent without nuclear testing.

The NNSA has directed the resumption of pit manufacturing in the US and has oversight of LANL's Pit Manufacturing and Certification Program. **NW**

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Senator Domenici addressing employees in the TA-55 auditorium said, "Stockpile Stewardship has been a fantastic success. It has been a pretty exciting life that I've lived and part of that is because of Los Alamos, and I thank you for that." Behind Senator Domenici, *left to right*: Glenn Mara, Principal Associate Director for Weapons Programs; Dan Glenn, Los Alamos Site Office Manager; Representative Wilson; Michael Anasasio, Director of LANL; US Marine Corps General James Cartwright, Commander of STRATCOM; and Steve Henry, Deputy Assistant to the Secretary of Defense.

debate based on facts. In my previous self-appointed role as spokesman for American nuclear policy, I have been trying for years to articulate those facts, but with limited success. We need to do better.

I think the biggest question in the area of doctrine and operations—indeed, arguably the most important question facing us in any nuclear area—is the fundamental purpose or purposes of nuclear weapons in the 21st century. I’m not thinking of the assure, dissuade, deter, and defeat typology. It is fine at the conceptual level. Rather, I think we lack consensus on the concrete types of situations (other than the residual role in deterring large-scale attack from Russia) in which nuclear weapons are relevant.

Even where we know that nuclear weapons are relevant, we lack consensus on the details of how they are relevant. A painful example: it seems self-evident that allowing a potential adversary a sanctuary beyond the reach of US power weakens deterrence. One such sanctuary might be within hard and deeply buried structures. Yet, one proposal to conduct limited research on adapting an existing weapon as a robust nuclear earth penetrator was greeted with outrage in many quarters. I believe some of the reaction had nothing to do with nuclear weapons, but reflected strong disagreements with the administration’s overall approach to the use of force. But we also saw reactions from those for whom the only legitimate function of nuclear weapons is deterrence, conceived of exclusively as involving the threat of retaliation against cities.

A second question in the area of doctrine has to do with the relationship between nuclear and nonnuclear capabilities. It is virtually certain that we will see an increasing use of nonnuclear strategic capabilities. The recognition that nonnuclear or nonkinetic capabilities can perform functions previously reserved for nuclear weapons was one of the most important insights of the NPR. Yet, the debate over the conventionally armed Trident teaches us that this concept is neither accepted nor, in some cases, well understood. Some believe that the NPR called for more use of nuclear weapons against targets previously assigned to a nonnuclear strike. Others believe (on grounds of arms-control theology) that there should be a separation between systems used to deliver nuclear weapons and all other military systems. Both of these beliefs are wrong, but they

are persistent. We need a better articulation of what the integration of nuclear and nonnuclear strike capabilities really means.

Finally, any review of doctrine might seek to clarify the role of so-called nonstrategic nuclear weapons. The title of the conference “Strategic Weapons in the 21st Century” will lead us inevitably to focus on central strategic systems. But whatever the military theories of the past, politically there is no such thing as a nonstrategic nuclear weapon. As we think through the role of strategic weapons in the 21st century, it ought to include the operational or political roles—if any—for battlefield or tactical or nonstrategic weapons, however we choose to call them.

The implementation strategy narrative for workshop discussion strikes me as thoughtful. The notion of distinguishing between readiness and responsiveness is a valuable construct and I hope that panel will spend much of its time amplifying it. One additional area of possible focus is new capabilities. Here I think we need to be very careful.

Most of you recognize that we have the wrong stockpile politically (it’s too big), the wrong stockpile from a physical security standpoint (it doesn’t consider the post 9/11 threat, which drives a security posture based on “denial of access” rather than “containment”), and the wrong stockpile technically (it’s based on maximum yield-to-weight ratio and low margins; it’s not designed for longevity; and it’s hard to remanufacture).

Many of us—including me—also think we have the wrong stockpile militarily. We think yields in the legacy stockpile are too high, that the stockpile lacks important mission capabilities (hard and deeply buried targets, mobiles, agent defeat, etc.), that too much of our capability is in multiple independently targeted re-entry vehicles, and that the stockpile is not geared for small attacks requiring both absolutely assured destruction of a limited number of targets and flexibility in command and control, using what is sometimes called the “silver-bullet” concept. We may be right, but that is irrelevant.

Thus far, the professional military has not chosen to embrace new capabilities. We need to avoid giving the appearance that there are new capabilities

being pushed by the labs. Technology may permit building devices that can generate tailored outputs, but absent some clear military requirement, calling for such devices will simply reinforce the perception of “busywork for scientists” embodied in the recent *New York Times* editorial.

Yet, it may well be that new capabilities will be required. But for now, we must concentrate, not on new military capabilities, but on retaining and strengthening the ability to respond to new military requirements in the future. “Responsiveness” must include such an ability. Determining how to preserve and exercise such a contribution within probable political constraints would be a valuable contribution.

The final panel is on science and deterrence. The recognition that science underpins deterrence is important. A strong deterrent grows from great weapons science and great weapons science grows from great general science, including, increasingly, the use of simulation, which many believe is becoming a third pillar of the scientific method along with theory and experiment. Thus, one task for the community is to consider how we can continue to have the weapons laboratories embody world-class science and engineering. This panel might help.

It would also be useful to identify the areas of science and technology where we have either new requirements or unusual shortfalls. For example, some might see radiochemistry as less important now that we are no longer engaged in nuclear testing. Yet, the growing requirements of nuclear forensics may require an expansion of the community. After all, we want states to believe that if terrorists acquire materials or weapons and use them against the United States, we will know where the material came from and will respond appropriately. That suggests a need for specific technical skills. There are doubtless many other examples.

In the long term, the strategic weapons of the 21st century will only retain their long-term effectiveness if they are supported by a transformed nuclear weapons enterprise. With Complex 2030, we are beginning that transformation. Our plan is easy to describe but difficult to implement. We need to

stop refurbishing some of the cold war stockpile and apply the savings to finance transformation to a stockpile that is easier to manufacture and certify, less costly, and easier to adapt to changing requirements. Thereafter we need to reduce the stockpile further, both for policy and cost reasons. While none of the panels directly address this transformation, it needs to be in the background of all of our minds. Policy, doctrine, rhetoric, and even operational concepts can change quickly. The Complex cannot. Sustained support for transformation will be crucial.

That brings me back to my opening caution. We need a coherent vision for our nuclear future that commands respect from Capitol Hill and strong support from the executive branch. We need a new, broad political consensus on nuclear policy in the post-cold war era. We even need a new arms control and nonproliferation strategy. Like it or not, this is still key to political acceptability in Congress and internationally. We are not likely to get any of those in the next two years faced with divided government, Iraq, indifference in the military services, the almost nonexistent Capitol Hill support for anything new, and the nearly imminent presidential campaign.

Does that mean we are wasting our time today and tomorrow? Not at all. We must do the intellectual work to prepare for the future. We must be willing to carry on a debate with folks who don’t yet know the “right” answer or have a different right answer from us. If we can’t have the debate earlier than 2009, we must be ready then with the concepts necessary for a meaningful review. That will be hard, but we must do it.

Nuclear weapons will be with us as long as anyone in this room is alive. The political conditions for abolition are unlikely and the technology to verify abolition doesn’t exist. Sooner or later nuclear forces, policy, and doctrine will once again play a commanding role in our national security strategy. Our task is to ensure that our nation is ready for that day.

Thank you for your attention. I’m looking forward to the results of your deliberations. *NWJ*

A BACKWARD GLANCE

Establishing the Nevada Test Site

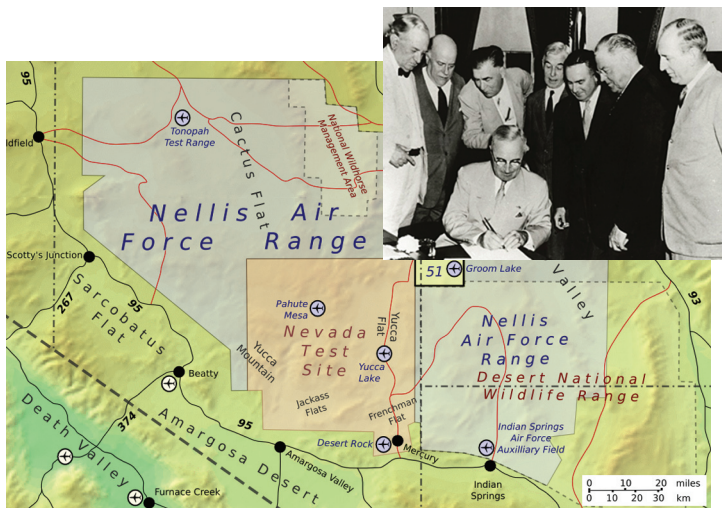
President Harry S. Truman designated the Nevada Proving Ground as the location for conducting nuclear weapons tests within the continental US in December 1950.

Los Alamos Scientific Laboratory delivered a nuclear assembly to a B-50 bomber at Kirtland Air Force Base on January 27, 1951. The bomber, along with two escorts, flew to the Nevada Proving Ground. The device was armed at low altitude. Then the bomber climbed to its designated bombing height, and after receiving approval from test officials, dropped the 1-kt device over ground zero on Frenchman Flat. This first test at the new proving ground was code-named Able.

Because little was known about the effects of nuclear weapons, tests were required. The tests served a variety of purposes related to national security, including testing to determine the feasibility of nuclear explosives for peaceful uses, testing to verify new weapons concepts, and proof-testing existing weapons to determine their effects on man-made structures and the environment. In the early years of testing, the US detonated nuclear explosives on the ground, underground, in the air, and underwater.

From 1951 to 1992, the DOE and its predecessor agencies, the Atomic Energy Commission (AEC) and the Energy Research and Development Association, conducted 928 nuclear tests at the Nevada Proving Ground, later known as the Nevada Test Site.

President Franklin D. Roosevelt established the Las Vegas Bombing and Gunnery Range in 1940 so that airplane gunners could practice. Located north and west of the City of Las Vegas, the range consisted of approximately 3.5 million acres and encompassed all of what is now the Nevada Test Site.



After the July 1945 Trinity test of the world's first atomic device at the Alamogordo Bombing Range in New Mexico, five nuclear tests were conducted.

The AEC and the Pentagon launched a feasibility study in 1946, code-named Project Nutmeg, to locate a nuclear testing site within the continental US. The study focused on areas where tests could be conducted without radioactive fallout causing human or economic harm.

Fearing the escalating tensions in Korea, the US again began discussions on a test site in the continental US in 1950. The AEC and DoD recommended three final site candidates: Dugway Proving Ground-Wendover Bombing Range in Utah, Alamogordo-White Sands Missile Range, and the Las Vegas Bombing and Gunnery Range. All three proposed testing sites were under government control, but the government also needed a site that was reasonably close to Los Alamos, did not have a major population center within a 125-mile radius, had little rainfall, and could be protected against penetration for security. The location also had to be an area where tests could be conducted with radiological safety for the adjacent population.

The Nevada site offered the advantages of existing barracks, a mess hall, and an airfield at Indian Springs. Las Vegas was nearby and offered commercial rail and air service, a labor pool, contractors and their equipment, and additional housing for workers and their families.

The Nevada Test Site began as a strip of land approximately 16 by 40 miles (approximately 640 square miles) and now consists of approximately 1375 square miles of remote desert and mountains. **NWJ**

President Truman signs the Atomic Energy Act of 1946, which established the Atomic Energy Commission (AEC) and transferred all authority from the US Army to the AEC. Truman called for the AEC to take over the Manhattan Project's material resources and to "...control all sources of atomic energy and all activities connected with its development." The AEC was a full-time, five-member civilian board that oversaw all atomic research and development in the US.

Indian Springs and Frenchman Flat where the first test took place are at the lower right of the map. In 1950, the US Air Force renamed the Las Vegas Army Airfield as Nellis Air Force Base and the Las Vegas Gunnery Range became the Nellis Air Force Range.



One of the five Operation Ranger nuclear tests conducted in 1951.