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Defense Programs

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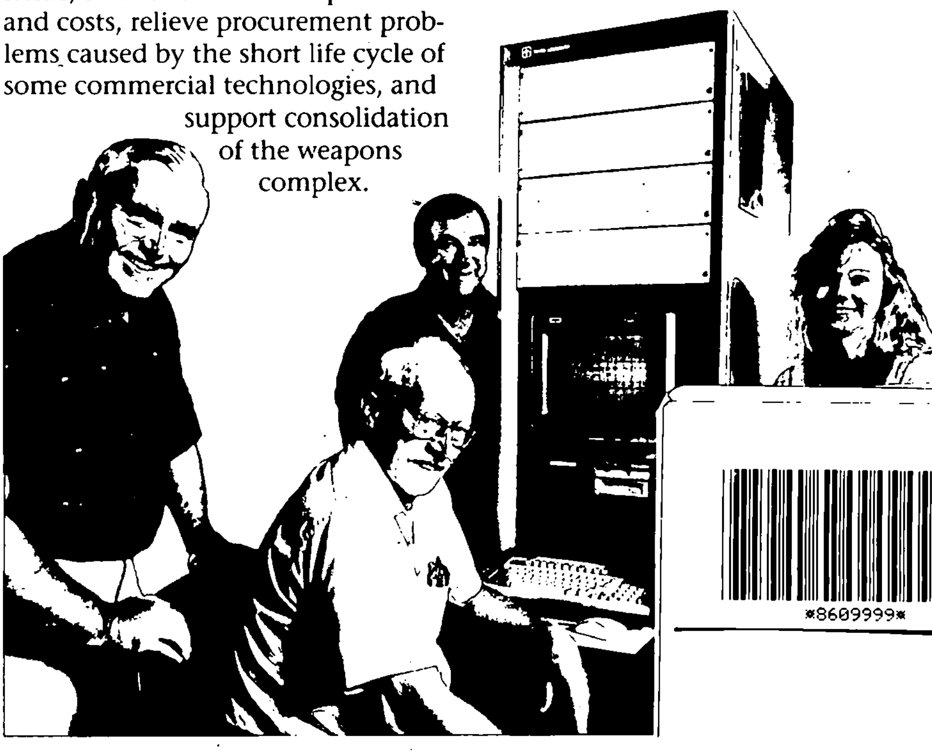
Focal Point and STEP

Decision-making processes for allocating resources

Sandia has always focused its advanced weapon development not only on future weapon needs, but also on the engineering and manufacturing sciences needed to meet them. Both areas are changing dramatically. As the nation dismantles many of its warheads, it becomes essential that those that remain are increasingly reliable, secure, capable, and safe. And as development resources diminish, it becomes vital that they are applied to the most critical technologies in a disciplined manner. The mission of the Focal Point program and the Stockpile Transition Enabling Program (STEP) is to develop processes for meeting these challenges.

Focal Point offers a decision-making process for allocating Sandia's resources to meet its defense programs strategic goals. It assesses needs, identifies technologies to meet these needs, integrates these technologies into suitable architectures, and selects promising architectures for further development. STEP addresses the standardization of components, subsystems, and processes that have broad application. By developing product lines to produce these standard items, STEP should reduce production schedules and costs, relieve procurement problems caused by the short life cycle of some commercial technologies, and support consolidation of the weapons complex.



Doug MacMillan (seated) and (l to r) Colin Hackett, Dennis Sparger, and Abigail Sieber at the control system for a paste explosive transfer experiment. This surety project is in the Focal Point prototyping phase, where it is approaching Milestone 2.

Defense Programs news in brief

DOE requests revolutionary surety concepts

In DOE's recent authorization of Phase 1 studies for a B61-diameter bomb and a cruise missile-size warhead, the DOE laboratories were asked to identify "revolutionary rather than evolutionary safety and security concepts."

J. Cuderman, *Org. 5161, (505) 844-8063*

Direct Optical Initiation program achieves milestone

A complete prototype optical firing system, which included a laser, optical stronglink switch, splitter/coupler, optical fiber distribution system, and optical slapper detonators, performed well during and after a broad range of thermal, mechanical, and radiative tests. Challenges in system development included preventing optical fiber damage from gigawatt laser pulses, maintaining flyer foil integrity, precise optical alignment, and optimization of explosives.

S. M. Harris, *Org. 2513, (505) 844-0949*

PRESS/SRAM A replaces W89/SRAM A retrofit

The W89 backfit for the SRAM A missile has been canceled and the program for Pit Reuse for Enhanced Safety and Security (PRESS) officially authorized. The current PRESS W89/SRAM A baseline is also being redesigned for compatibility with other weapons in the enduring stockpile. The PRESS program plans to carry forward the essential elements of the W89 design—elements such as the Reuse Pit, the Detonator-Safing Strong Link, the Single Stronglink Assembly, and the Firing System.

E. T. Cull, *Org. 5354, (510) 294-2634*

B57, B61 field retrofits are complete

Field retrofits that enhance the nuclear safety of the B57 and B61 during peacetime air transportation have been completed ahead of schedule.

J. M. Donaworth, *Org. 5514, (505) 845-8480*

High-altitude radiation damages W88 JTA telemetry systems

Unexpectedly high mid-flight radiation has degraded the performance of W88 JTA radio telemetry systems—through radiation-induced latch-up or single-event upsets in signal processor semiconductors. Revision of interface requirements to include in-flight radiation exposure is being considered.

H. V. Fisher, Jr., *Org. 2665, (505) 845-8272*

PRONTO3D has a new surface algorithm

The transient dynamics code PRONTO3D has a new contact-searching algorithm that also can define new surfaces that result from material failure. By thus being able to include such effects as metal tearing, penetration, and blast-debris tracking, modeling of weapon nuclear safety calculations will be much more accurate.

S. Attaway, *Org. 1425, (505) 844-9288*

MAST hydrodynamic tests are successful

The Multi-Application Surety Technology (MAST) Warhead project is a joint engineering effort focused on developing warhead designs that offer modern surety technology options for the enduring stockpile and for future military needs. A hydrodynamic test successfully fired at Los Alamos provided data for evaluating Sandia component standoff characteristics and Los Alamos explosive-package performance. A laydown simulation test yielded high impact shock data for a B61/MAST configuration.

M. A. Rosenthal, *Org. 5167, (505) 844-6728*

Together, Focal Point and STEP establish a methodology for selecting technologies and designs for transition from exploratory development to Focal Point prototyping (Milestone 1), to STEP engineering and manufacturing development (Milestone 2), and finally to a standard product line (Milestone 3). Two teams make these selections. A **Review Team** of program managers from systems and component organizations annually recommends Milestone 1 transitions to the Defense Program managers. A **Management Team** of weapon program managers, component organization directors, and representatives from the DOE and the production agencies, meets only when a Milestone 2 or 3 transition decision is needed.

Focal Point is currently supporting several surety activities related to inherently safe and secure weapon architectures and assessment methodologies. STEP is looking at expanding Sandia's standardized component qualification program to include a broader set of requirements so that components could be used in more programs without requalification. It is also considering the degree to which standardization is appropriate for the weapon program. Specific components and subsystems are now going through Milestone 2 reviews, and evaluation of proposed product lines has begun. Focal Point and STEP should strengthen Sandia's role as a steward of the nation's nuclear stockpile, and should keep Sandia in the forefront of relevant engineering and manufacturing developments.

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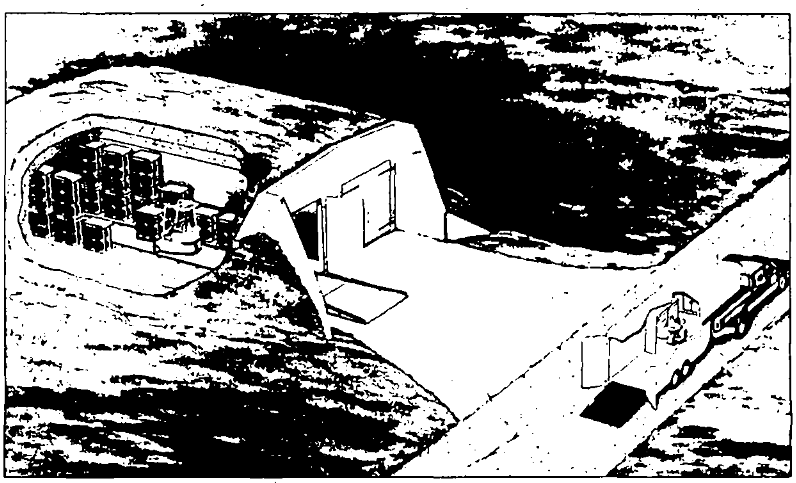
Dismantling the nuclear stockpile

Increased concern for the environment introduces new challenges

Dismantlement has been taking place routinely for decades, but new agreements with Russia have so accelerated stockpile reduction that new processes are needed. Sandia's mission in this downsizing is to assist the DOE with direct planning and management, direct technical support of the dismantlement, and indirect technical support for improving the processes.

Dismantlement begins with DoD weapon retirement and ends with DOE disposition of warheads, bombs, excess weapon components, trainers, handling equipment, and other accessories—a procedure that includes transportation, storage, and disassembly into subsystems and components that are then either disposed of or staged for reuse.

Because robots are well suited for the hazards of dismantlement, they will be used in the disassembly of explosives and radioactive parts and for separation of materials for disposal. And, because it is imprudent for workers to enter igloos containing high density radioactive material, Sandia is also developing a system called Stage Right (see illustration) that uses remotely controlled forklifts to load, unload, and inventory the material.



Stage Right storage igloo designed to accommodate remotely controlled forklifts that load, unload, and inventory hazardous materials.

Sandia systems analysts are supporting dismantlement with automation of dismantlement directives that provide early forecasts of the return and staging rates of retired weapons. And they are analyzing the processes for security and safeguards, retirement and disassembly prioritization, and risk assessment and management. Engineers are developing computer simulation models and strategic assets management techniques to improve the transportation and staging of weapons.

The nation's increased concern for the environment introduces new challenges in the disposal of materials. For example, new federal and local regulations require that certain materials scheduled for disposal be identified—materials such as lead in solder, copper in electrical wiring, mercury in switches, and selenium in rectifiers. Original assembly drawings do not describe these materials in enough detail to satisfy the new regulations, so sampling and material analysis techniques and a materials database are being developed to meet this requirement.

Disposal of a subsystem often requires declassifying, demilitarizing, and sanitizing. Engineers are exploring processes that perform these functions simultaneously—acid digestion, shredding, and grinding, for example. One method that looks promising is cryofracture—immersing a component in liquid nitrogen to embrittle it, then fragmenting it with a forge hammer. Such solutions are vital, because dismantlement is under way and the need is immediate.

For more information, call
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W88/MK5 Arming, Fuzing, and Firing system meets all requirements and goals

Making the Trident II SLBM more effective

The W88/Mk5 AF&F was delivered on schedule after a five-year development program sponsored by the DOE Defense Programs Office and the Navy Strategic Systems Project Office. Hardware and software advances designed into this AF&F by Sandia contribute to the effectiveness of the Trident II Sea Launched Ballistic Missile system. And Sandia's share of the program budget, which did not include contingency funds, was only 3.6 percent overspent—less than the customary contingency allowance.

Conformance to requirements was demonstrated by testing 63 AF&Fs to nuclear radiation, lightning, fire, crush, flight, transportation, handling, and storage. No design changes were suggested by the data, so the testing ultimately served to confirm the design rather than to detect flaws.

The AF&F incorporates several advances in arming, fuzing, and firing technology. The radar-updated path-length fuzing option compensates for missile guidance and navigation errors by adjusting fuzing altitude—one of the unique features that make the W88/Mk5 very effective. Radiation-hardened semiconductors and special circumvention hardware and software enable the AF&F to function through nuclear radiation. A microcomputer in the Programmer assesses the performance of various subsystems and invokes alternate fuzing options if it detects a malfunction.

Don Tipton holds a W88/Mk5 Arming, Fuzing, and Firing system that has had its cover removed. The Firing Set is at the bottom and the Programmer is under his left thumb.

Digital signal processing in the Radar achieves immunity to jamming by enemy countermeasures. A proximity-burst option in the radar provides flexibility in targeting. Special stronglink switches isolate critical firing circuits by magnetically coupling energy into them only after receipt of a unique signal. And the small size and low power consumption of CMOS large-scale integrated circuits allowed a compact design that met severe packaging constraints.

Interactive management contributed to the program's success. It provided early requirements to the subsystems organizations and carefully managed subsequent changes. A project plan to meet the collective goals and requirements was negotiated among all working groups. The customer received periodic reports to ensure clear understanding of progress, risks, issues, and plans. Production agencies were partners in the development process from the beginning. And the project received crucial support from specialists in a variety of disciplines — physical and computational simulation, engineering sciences, pulsed power, and materials and process engineering.

For more information, call
D. D. Tipton, *Org. 5151, (505) 844-1045.*

The Common Radar Fuze

Quality through design for manufacturability

Design for manufacturability means adequate design margins, production processes well within the manufacturer's capabilities, and continuous improvement to eliminate problems as they occur. Designers must address all steps in fabrication, assembly, and testing to create designs that simplify manufacturing and testing. Sandia engineers have designed the Common Radar Fuze with just such attention to manufacturability.

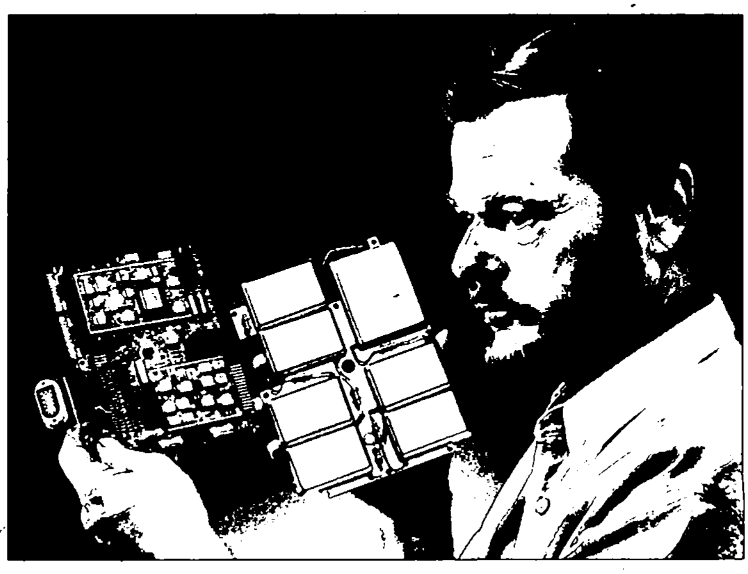
The Common Radar Fuze, a compact dual-channel radar designed for nuclear bombs, will be used in the B83 as part of its forthcoming quality improvement program, and it probably will replace the vacuum-tube radars in some versions of the B61. Thus, this radar likely will be produced for a decade and remain in the stockpile for many decades after that.

Because of the quality needed for such a long stockpile life, the design team emphasized manufacturability from the beginning of the program. Allied Signal team members were resident at Sandia during conception of the radar and its test equipment, and Sandia team members worked with Allied Signal on manufacturing details, including the layout of the production area. They designed the radar to have a manufacturing cycle time of only six weeks—about optimum for timely detection and correction of production problems.

Engineers focused on four areas to make the radar more manufacturable:

- component selection to reduce parts count
- circuit design for simple and automatic assembly
- rugged, independently testable subassemblies
- a common package for radio frequency (rf) hybrid circuits

A flex circuit interconnect and a slip-fit connector can be seen on the subassembly in George Steigerwald's left hand. Note that six of the hybrids in his right hand have identical packages.



An example of designing for easy assembly is the modular approach used for the rf hybrids. Each hybrid contains its own mechanical attachment, shield can, and rf cables, which allow testing to the real interface that the hybrid sees in the radar while providing ample handling protection. This eliminates the problems of handling damage and incomplete hybrid testing.

Modular design and slip-fit connectors simplified assembly.

This modular design, however, added connector-pairs that required mating at the final radar assembly level. Unfortunately, a mismated connector can cause either an immediate failure that requires rework, or degradation of radar performance over time. Engineers solved this problem with slip-fit connectors and special insertion tools that prevent mismating. And this manufacturable combination of modular design and slip-fit connectors replaced a complex assembly operation and simplified rework of the rf assembly.

Flex circuits that connect the radar subassemblies to the power connector further simplify assembly by eliminating individual wires and lead frames. Also, because assemblers now solder only outside the radar housing, they encounter less circuit miswiring and solder-splatter. And the final electronic assembly can be cleansed of foreign-particle contamination before being installed in the radar housing.

Manufacturing errors can account for most of the rework in a complex electronic assembly. By improving the manufacturability of the Common Radar Fuze, Sandia engineers may set a new standard for the manufacture of electronic subsystems for nuclear weapons.

For more information, call
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Insertable-explosive arming of firing sets

Physically separating critical firing elements improves safety

Sandia has long played a major role in improving the nuclear safety of the nation's stockpile, with much of the improvement being made with intrinsically safer firing sets—those having exclusion regions and stronglink switches, for example. Sandia engineers have added a new dimension to this intrinsic safety by physically separating critical elements of their firing set until arming time. By designing insertable-explosive arming into a compressed magnetic field (CMF) firing system, they have not only improved safety, but also packaging efficiency, cost-effectiveness, and robustness.

A CMF firing system without its explosive is absolutely inoperable.

A CMF firing system is an explosive-to-electric transducer that uses a carefully controlled explosive deformation to transform arming current into the proper electrical signal for firing detonators. The deformation expands a conducting armature into a closely wound coil that is carrying the arming current. This rapid movement of the armature changes the inductance of the coil in such a way that the arming current flowing in the coil is transformed into an electrical signal that fires detonators.

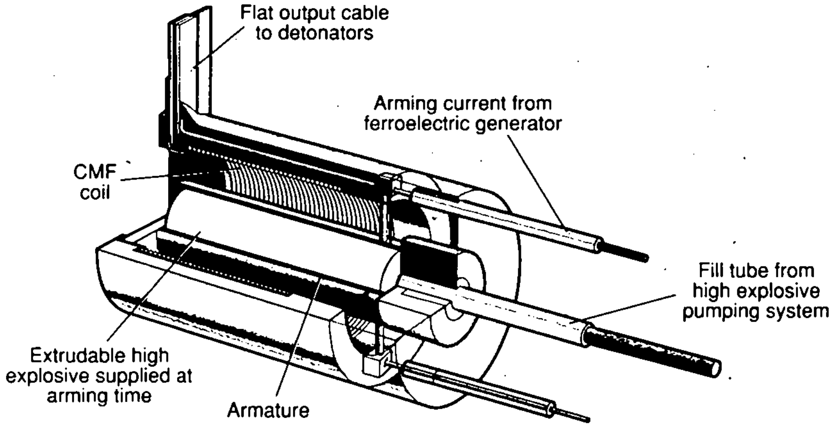
In a CMF firing system modified to use an insertable high explosive, the explosive is stored separately from the firing system, thereby rendering the firing system absolutely inoperable. A stronglink valve, which operates only when it receives a unique signal, isolates the explosive from the CMF.

Arming occurs when the explosive—either a solid rod or an extrudable paste—is inserted. In the Small CMF Firing Unit shown in the figure, an extrudable paste explosive is pumped through the explosive fill tube into the firing unit's armature. In this system another explosive firing unit using a ferroelectric generator supplies the arming current, but it could have been supplied by a capacitive discharge unit.

A CMF firing unit can fire not only the traditional exploding bridgewires, but also the exploding-foil initiators known as slapper detonators. It can be scaled down to fire one detonator or up to fire many. Because a CMF unit has only a few mechanical parts—tubes and coils—it is simple to build and robust enough to meet a wide range of applications, including use in an earth penetrator.

Other explosive-to-electric transducer technologies being developed at Sandia include the Slim-Loop Ferroelectric and the Ferromagnetic arming-current generators—all using explosive energy to create the short-duration, high-power electrical current and voltage pulses needed for firing detonators, and all candidates for insertable explosives.

For more information, call
T. J. Williams, *Org. 2571, (505) 844-3356,or*
W. C. Curtis, *Org. 2571, (505) 845-9649.*



The Small CMF Firing Unit uses a paste extrudable explosive that is pumped into the firing unit's armature through the explosive fill tube at arming time. Arming current is supplied either by another explosive firing unit using a ferroelectric generator or by a capacitive discharge unit.

Preparing for fewer underground tests

An integrated plan to deal with the test limitation issue

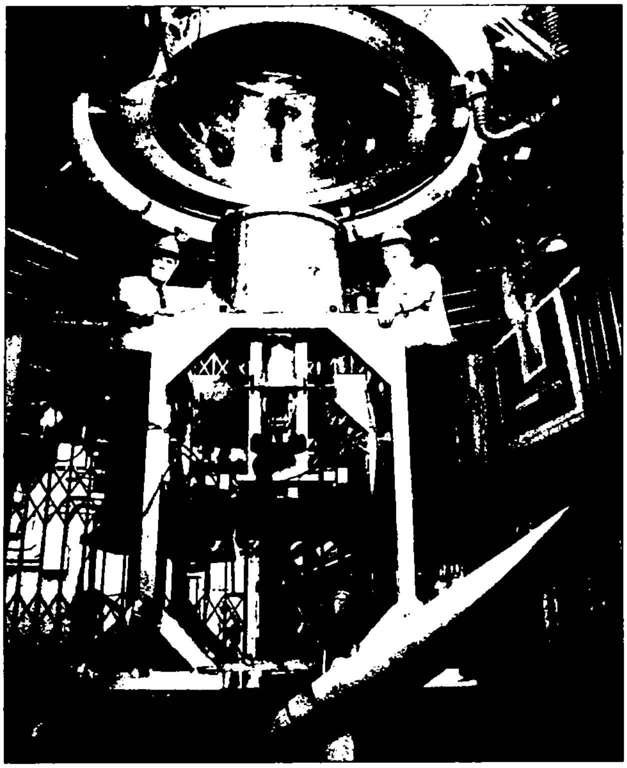
Congress has mandated that the DOE weapons laboratories prepare for further limitations on nuclear underground testing (UGT). In fact, recent Congressional actions suggest that a one-year moratorium on UGTs could begin as early as October 1992. Unfortunately, verifying that weapons can operate reliably in radiation environments still requires UGTs—today's aboveground test (AGT) simulators can't produce the right environments over adequate test volumes, especially for exposures of systems to soft x-rays and fast neutron pulses. Sandia worked with the Defense Nuclear Agency (DNA), Los Alamos National Laboratory (LANL), and Lawrence Livermore National Laboratory (LLNL) to develop an integrated plan to deal with the test limitation issue—a plan that includes AGT/UGT correlation programs and improvements in aboveground facilities.

Sandia worked with DNA, LANL, and LLNL to develop an integrated plan.

Changes in the stockpile over the next few decades probably will require radiation testing of weapon systems, subsystems, and components. There will likely be revised deployment scenarios. Many weapons will be upgraded with safer electronic subsystems, and some will be redesigned to reuse existing pits. Because a smaller stockpile places a premium on safety and reliability, these modifications should be tested for operational reliability in radiation.

Because there may be only a few UGTs remaining, preparation for further limitations calls for action in several critical areas. The first step is to proceed with correlation programs that extend the range of system certifications that can be done with AGT alone. The next step is to improve AGT simulators. Sandia, DNA, LANL, and LLNL concur on the environments that need improvement—cold and warm x-rays, short-pulse neutrons, and larger area gamma and x-ray exposure—and propose constructing new facilities to do so.

One proposed facility is the Externally-Driven Nuclear Assembly (EDNA).



Ted Wrobel (left) and Dave Beutler stand beneath the Saturn x-ray facility after making final adjustments for an exposure of an electronic subsystem designed to operate through nuclear explosion radiation. Conducted in cooperation with DNA and SDIO, this test required synchronization of the Saturn pulse with the circuits under test and complete monitoring of the circuit response before, during, and after the exposure.

This scheme is based on Sandia's HERMES III x-ray facility and evolving reactor designs, and uses modern linear induction accelerator and fast-burst reactor technologies. EDNA could irradiate warhead systems with extremely short neutron pulses, very high fidelity source-region EMP, and combinations of gamma rays followed by neutrons. A second new simulator is a cold and warm x-ray facility for testing materials and structures. The environments to be simulated by these and other possible facilities exist today only in UGT.

Over the past several decades the radiation-effects community has evolved a balanced methodology for establishing the radiation hardness of weapon systems—a methodology that combines the unique contributions of analysis, AGT, and UGT. Without the UGT leg of this triad there would be more uncertainty in AGT results, a need for much more analysis, and a real risk that new vulnerabilities of modified weapons would go undetected. Although we cannot yet certify systems without UGT, the proposed program of AGT/UGT correlation, simulator improvements, and appropriate UGTs could solve many of the problems posed by further UGT limitations.

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