Nuclear Weapon Overview

SAND2006-6741P

July 25, 2006

"America's Nuclear Weapons Engineering Laboratory"

Letter from Joan

Joan Woodard
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Deputy Laboratories
Director for NW

This is a new era for nuclear weapons and their development and the maintenance of the nation's nuclear deterrent. On the international scene, the Cold War and the associated bi-polar world is over. We now face the rise of multi-factionalism and the complex that arises from it. We seek a capabilities-based deterrent aligned with our new triad, derived from the Nuclear Posture Review. Due to our seminal mission areas within the nuclear weapons enterprise and the changing mission space, Sandia continues to have core responsibilities in its role to sustain the nation's stockpile and nuclear deterrent.

We are stepping up to these evolving challenges by stepping up to a collection strategic objectives. We will ensure a credible, transformed nuclear weapon stockpile for the nation by increasing our technical knowledge base through innovative evaluation techniques and implementing a Common Adaptable System Architecture (CASA). We will achieve a transformed nuclear weapons enterprise with capabilities responsive to changing environments and threats, by leading all non-nuclear product realization, and by providing the technical support to systems integration for the complex, through demonstrated performance. We will provide integrated surety through predictably safe weapon response in all environments at all times without exception, and assure absolute control and security of nuclear assets independent of the threat without compromising reliability. We will accelerate engineering innovation through the integrated application of simulation, scientific understanding, and testing.

Ultimately, we will realize our new vision: *Credible deterrence built on both a safe, secure, and reliable nuclear weapons stockpile that is capable of meeting all military requirements – now and in the future – and a science-based engineering infrastructure capable of responding to national security needs whenever they arise.*

(Signed) Joan Woodard

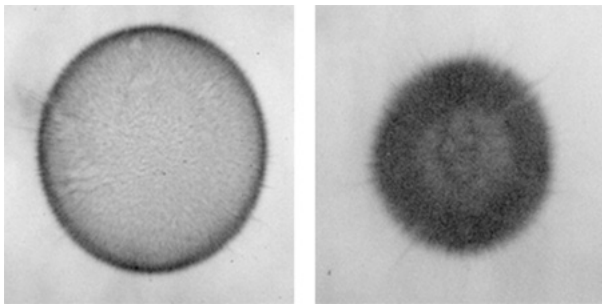
Sandia National Laboratories

In this issue:

Accomplishments

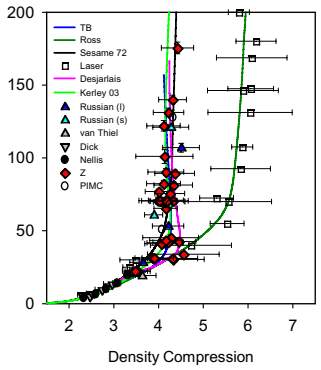
Pulsed Power

Sandia's pulsed power capabilities are being utilized by all the nuclear weapons laboratories in their quest to determine the fundamental properties of materials critical to the understanding of nuclear weapon performance. Prior to a scheduled shutdown of the Z facility, a collection of plutonium equation of state experiments was performed. In collaboration with LANL, two secondary assessment issues called "Features" and "Canis" were addressed. Testing was performed to determine the shock melt characteristics of national ignition facility (NIF) ablators. Z experiments successfully demonstrated pulse shaping techniques for isentropic compression experiments (ICE) and obtained tungsten and tantalium data to 3 Mbars of compression. The Sandia pulsed power facility obtained a record neutron yield on a x-ray-driven beryllium-shell capsule implosion.



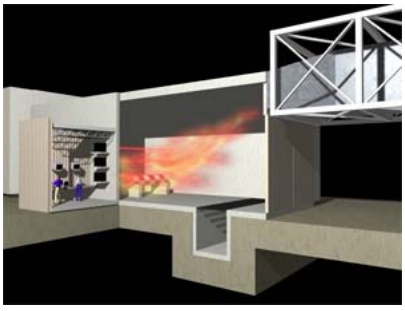
Implemented capability on a single Z shot to obtain two backlit Z-Beamlet images

Z-Refurbishment scheduled to start July 2006.

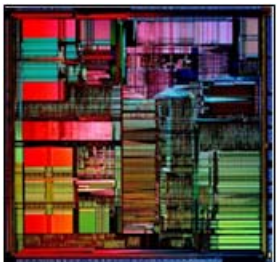


W76-1 Life Extension

The W76-1 life extension program is now in phase 4, production engineering. In terms of component deliveries, the program has received the A3984 permafrost application specific integrated circuit and the qualified MC4695TRA arming fuzing and firing simulators. Testing has been successfully completed at the light initiated high explosive facility. At the Thermal Test Complex of the Crosswind Test Facility, the JP-8 fuel fire tests have been completed.



XTF



ASIC

Light Initiated High Explosive Hostile Shock Simulation

Accomplishments cont.

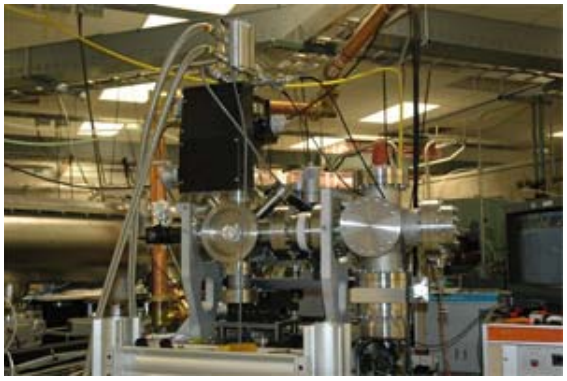
Reliable Replacement Warhead (RRW)

The current design completion continues and the design teams are working on the final cost estimates and input for NNSA transformation/process. Key to the evaluation of the designs is the definition of technical maturation necessary for each design and each team is finishing the execution of that assessment. A series of reviews for the designs are on-going with the recently completed program officers group (POG) review completed the end of June and the POG Executive Evaluation Team (PEET) reviews to be done the first of August. Sandia has completed its internal management reviews. Additionally, Sandia presentations were given to workshops and a review of RRW by the American Association for Advancement of Science (AAAS).

waiting for picture

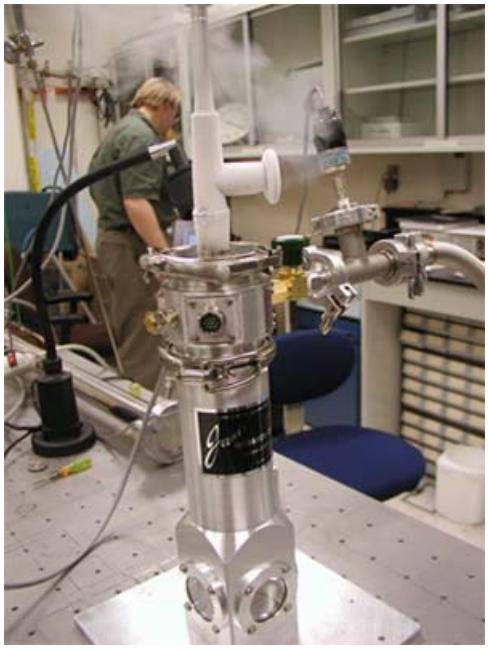
QASPR - Qualification Alternatives to SPR

The cryogenic neutron testing of components and sub-systems has been demonstrated at multiple facilities. The purpose of the testing is to reduce defect kinetics for the validation of models. Damage equivalences have been assessed at a collection of facilities including Sandia Pulsed Reactor, White Sands Missile Range, Los Alamos Neutron Science Center, and Ion Beam Laboratory.



DLTS Cryogenics at IBL

The tests measured active gain with a liquid helium cryogenic system and showed equivalence between White Sands reactor and Sandia Pulsed Reactor gain as a function of temperature at fluences between 3 to 6 $*10^{13}$ n/cm^2.



SPR cryogenic set-up tested on bench top

Accomplishments cont.

Non-Nuclear Production Startup for W76-1 at Kansas City

• This effort is to engage the management of the Kansas City Plant to successfully schedule and produce the W76-1 life extension components and sub-systems. A collection joint plans have been developed and a series of bi-weekly "negative-slack" meetings have been held to manage Process-Prove-In and Quality Evaluation schedules. The management teams are conducting joint Producibility Reviews at the components level and Production Readiness Reviews at major assembly levels.

Kansas City Plant

Deployment of W87 Warhead on MMIII:

Due to changes in the force structure, the W87 warhead is required to be deployed on the Minuteman III (MMIII) missile as a singlet. This warhead was originally designed and qualified in the 80's for deployment in the Mk21 reentry vehicle in a MIRVed configuration on the Peacekeeper ICBM. To make the transition to the MMIII, the DoD had to modify their missile system to be compatible with the W87, and the NNSA labs (SNL and LLNL) had to qualify the W87 for this new application.

Evaluation and tests have shown that the W87 is compatible with the MMIII interfaces and environments, and that the warhead will meet its nuclear safety requirements on MMIII. Two successful flight tests on MMIII have confirmed proper operation of warhead functions and that environment levels are as expected. The W87/Mk21 on MMIII will provide a weapon system that has the safety features that were outlined by the Drell Panel study in 1990.

MMIII Launch at Vandenberg AFB, July 2005.

Accomplishments cont.

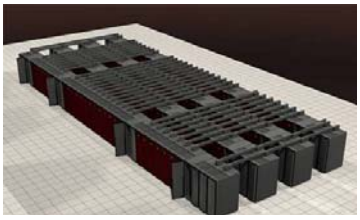
Red Storm

The Red Storm supercomputer achieved Limited Availability status on Sept 30, 2005, and ownership was transferred from the Computation, Computers, Information and Mathematics Center (1400) to Sandia's production Computing and Network Services Center (4300).

During FY06 we have continued to upgrade software and hardware in order to achieve General Availability status on both the classified and unclassified side by March 2007, while simultaneously running very large processor simulations for the stockpile. Sandia has run Fuego and Salinas simulations using up to 5000 processors in support of the W76-1 AF&F qualification, and both LLNL and LANL have conducted simulations with their codes using 1000's of processors.

Users have reported tremendous satisfaction with Red Storm and also satisfaction with the user support provided by Sandia. In recent performance studies Red Storm has demonstrated superior scaling to Blue G/L and Purple on applications codes from not only Sandia but also the physics laboratories.

In 2006 we are expanding Red Storm from four to five rows, which will increase the theoretical peak performance from 44 to 54 Tflops. Also in 2006 we have begun the Red Storm upgrade, replacing the 2.0 GHz Opterons with 2.2 or 2.4 GHz Dual-core Opterons. In 2007 we will complete the Red Storm upgrade by increasing the per-processor memory from an average of 3 Gb/proc to 8GB/dual-core processor. This will culminate in a theoretical peak performance of 125 Tflops.



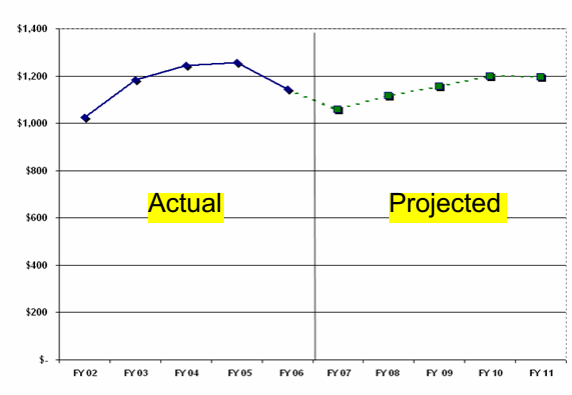
Pantex Thorough-put Improvement Plan

The backlog of work at the Pantex plant in Amarillo has become a significant concern for the nuclear weapons enterprise. The need to dismantle retired weapons while both assembling modified or altered weapons and perform needed surveillance on the systems in the stockpile has not been executed in a timely and efficient process as possible. Sandia, Los Alamos, Lawrence Livermore, and Pantex management have formed a team to: review the effort being executed at Pantex; study means by which thorough-put improvements can be made; and execute efficiencies that will provide greater productivity for the enterprise. Using such business efficiency tools as lean, six sigma, and value stream analysis, the management team is attempting to determine and eliminate root cause problems to greater thorough-put. This program is important because it serves as one of the business efficiency pilots for the transformation of the nuclear weapons complex into a more efficient and more effective enterprise. The lessons learned and the development of shared incentives will assist the complete transformation of the complex t support the nation's nuclear deterrent.

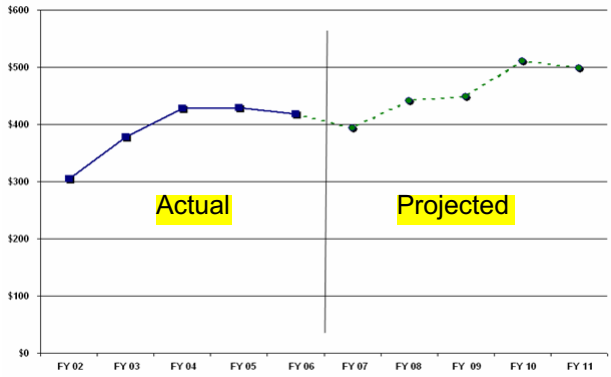
CHALLENGES

Financial

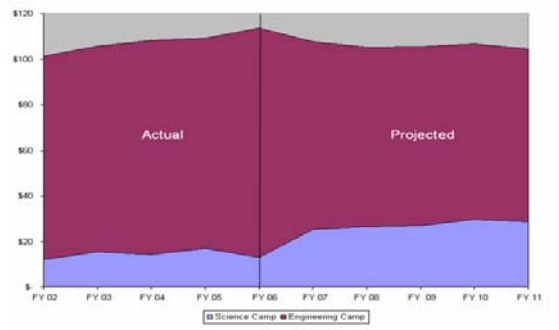
One of the keys to the smooth execution of the nuclear weapons program at Sandia is sufficient and sustained funding. The four charts below show Sandia's historical and projected funding for the overall nuclear weapons program and three major program areas: directed stockpile work, engineering and science campaigns, and the Required Tech Base Facilities.



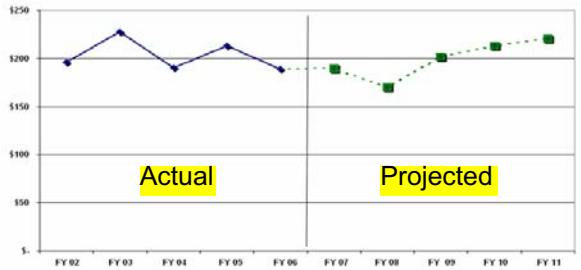
Sandia NWSMU Total Funding FY 02 - FY 11



Sandia DSW Funding FY 02 – FY 11



Sandia Engineering & Science Campaigns Funding FY02 - FY11



Sandia RTBF Funding FY 02 – FY 11

- Dip in overall funding anticipated in 2007 is creating a pinch within Sandia's NW program
- DSW funding increase involves changes in the system accounting and does not represent a real increase in funding
- Losses in engineering campaign funding are real and increase risk for the overall program
- Increase in science campaign funding is unprecedented, unlikely to be sustained, and does not compensate for engineering campaign losses.

CHALLENGES cont.

Programmatic Challenges

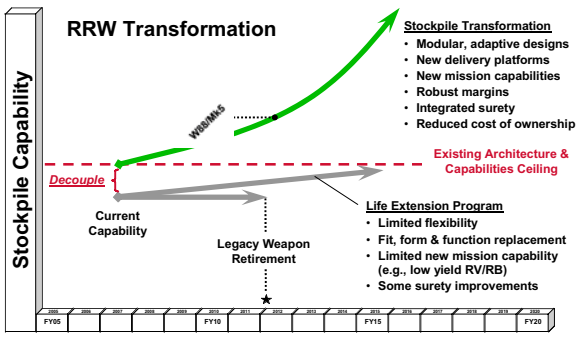
- W76-1 Design and production costs
  - Making sure that the costs of the system do not escalate during the design to production cycle
  - Maintaining system engineering controls to meet customer needs
- Strategy for the B61
  - Refurbishment needs require major overhaul of the system
  - Developing priority within NNSA funding and programmatic directions
- B61 spin rocket motors
  - Fulfilling requirements within system engineering controls
  - Meeting operational requirements
  - Maintaining specifications through sub-contractor production
- SNM disposition
  - Removing materials from the site on schedule and cost
  - Meeting testing requirements for the future
- Status of retired weapons – B53 and W84
  - Establishing the correct priority of dismantlement
  - Describing and validating safety issues for storage and transportation
- Cancellation of the W80 LEP
  - Maintaining capabilities to meet future system requirements
  - Maintaining "critical mass" through workload balancing of system organizations
- Sustaining minimal operations at Z for 2007
  - Meeting the continuing demand for Z capabilities with existing funding
  - Developing National Plan
- Complete Z-refurbishment
- Technical risk for QASPR
  - Obtaining usable data sets from QASPR experiments
  - Working the full spectrum of modeling/simulation issues

What we are Currently Working On:

RRW-1

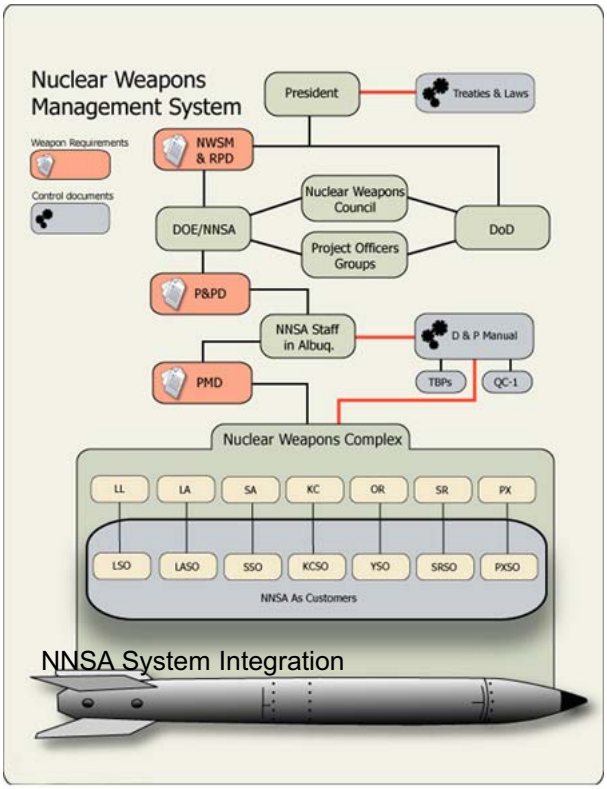
The first design study of the reliable replacement warhead (RRW) concept has just completed its first design submittal for review, modification and, ultimately, design team selection. The study of RRW-1 examined the specific development of a reentry vehicle for either the Navy or Air Force. The warhead designs from both New Mexico and California design teams represent significant departures from the systems in the current stockpile. With a heavy emphasis on aspects such as: confidence in reliability, surety, ease of manufacture, and flexible deployment; the RRW-1 study moved away from the traditional reentry vehicle design metrics of mass, volume, and special nuclear material.

The overall success of the nuclear weapons enterprise is tied to the efficient and effective development of the RRW concept. It is essential that the correct design path be established in this program. There is a need to make sure that the innovation of the design will assist in the more cost-effective deployment of the weapons system for the life of the program and the changes of the design will, in fact, be easier and cheaper to manufacture for a "right sized" complex.



Systems and Technical Integration Support

Critical to the efficient and effective transformation of the nuclear weapons complex from its current state of operation to an enterprise that meets the current and future needs of its nation and does so flexibly and responsively is the establishment of a systems engineering and integration contractor. This contractor is envisioned to support the needed decisions of the administration through an assessment process that is both thorough and transparent. NA-10 has committed to Congress to "Acquire, in 2006, a systems engineering, and integration contractor to support more broadly, NNSA decision-making on weapons…"



NNSA System Integration

This support must provide data-informed assessments of the program encompassing all the plants, the laboratories, the requirements from policy makers, DoD planning and operations, and the associated ES&H and security obligations. The integration activities will address both near and long-term mission needs. There is a collection of immediate stockpile issues requiring integration support and they include surveillance, cross-cutting programs within Directed Stockpile Work, tritium extraction, and the development of an integrated stockpile plan by the end of calendar year 2006.

Flight Test Strategy for the Future

With the potential closure of the Tonapah Test Range (TTR), the nuclear weapons program must wrestle with the need for high fidelity testing including the use of SNM for full system operational tests. This test strategy involves more than TTR. The other laboratories, the development and manufacture of high fidelity joint test assemblies, and the viable use of other testing facilities such as White Sands or Elgin for such tests may have a role in the development of the future testing strategy for the NNSA. Key to the strategy is the need for such testing at all.


B-61 Drop Test

Clarifying the Role of Nuclear Weapons for the Future

Changes in the overall stability of Europe and Asia and the advent of global terrorism have altered the way the nation's nuclear stockpile is being considered in the minds of policy makers. As discussed in the Nuclear Posture Review, the Nuclear Capabilities Task Force of the Defense Science Board, and congressional appropriating legislation, major changes will be made to the national stockpile. The United States needs and will have a smaller nuclear stockpile. The remaining weapons will need to be less costly to design, manufacture, and sustain. Yet, the threat of nuclear weapons has not been eliminated so that the stockpile will need to be as capable as before. The threat of theft or sabotage needs to be considered more thoughtfully and sharply.

The ability to rapidly respond to changing mission requirements needs to be integrated into the designs of the future. With smaller numbers of weapons, they will still need to project the full spectrum of capabilities that the current stockpile. In fact, the weapons of the future will need the flexibility to add features and capabilities that are not part of the current stockpile.

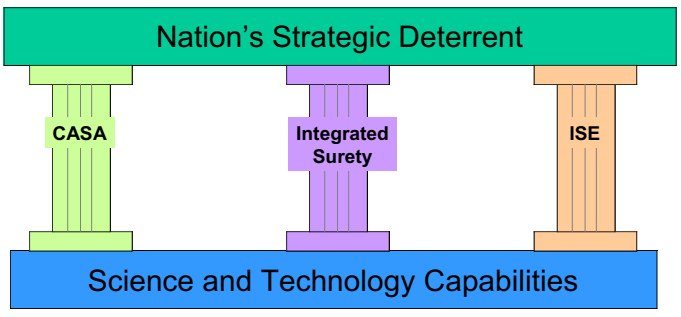
The threat of sabotage or weapon capture needs to be more prominently considered in future stockpiles. Reliance on large numbers of weapons is a feature of stockpiles of the past. The loss of a few weapons into the hands of groups that do not fear to use them is an unacceptable outcome in the world of tomorrow. Our weapons must be part of the security system used to secure them from such threats.

SLBM Launch

Anticipating the Weaponization Needs of the Stockpile of the Future

Sandia has the mission of maintaining the technologies and design space for the weaponization of nuclear designs for both physics laboratories. Sandia has executed that mission from its inception and will continue in this role for the foreseeable future. Although the mission space is not changing the way Sandia will do its work will be altered through an integrated system of initiatives.

The basis of these initiatives is the science and technology competencies developed at Sandia over the last sixty years coupled with state-of-the-art modeling and simulation capabilities developed enhanced since the end of the Cold War. Grounded in basic material and physical properties, validated by testing and modeling through sophisticated computer codes, the structure of sub-component materials and their responses to the complete environments of the stockpile-to-target sequences and the other abnormal and hostile environments will be understood at a fundamental level. This science-based knowledge will be used to permit complete understanding of the design space and the consequences of deployment and associated aging. This understanding underpins the three pillars of future

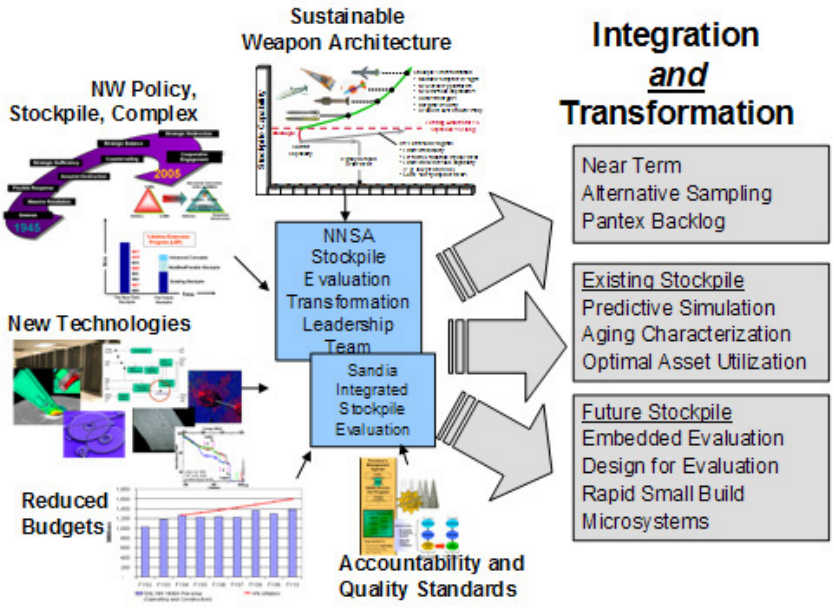


weaponization design work for Sandia; the development of a new system architecture, a system to fully integrate surety for nuclear weapons, and a new stockpile evaluation system that will take advantage of all past data collection.

The new architecture, called the Common Adaptable System Architecture (CASA), will take on the requirements identified for the future and meet them just as the systems of the past met theirs. CASA will approach these requirements through the use of integrated subsystems which will be small packages developed through advanced technology, and modularity. Built around a centralized controller that establishes standardized interfaces among the subsystems, CASA designs will be able to accommodate the features identified by the military today and have the flexibility to meet the unanticipated needs of the future. Through an expandable controller, CASA will be able to expand to significant mission changes in a less costly and more responsive way than any design from the past. A collection of possible expansion modules could include: flight path sensors, strong paths, weak paths, self test subsystem, guidance/navigation package, sensors for self assessment, protective membranes, umbilical links to integrated external systems, and penalty subsystems.

To this point in nuclear weapons design, nuclear weapons surety has been a standalone process with the surety systems integrated within the functions and operations of the weapon but not with the external surety umbrella associated to weapons storage and handling. The new concept, Integrated Surety, would link the internal capabilities and status of the weapon with the capabilities and status of the external world. It is envisioned that this linkage could be implemented in a number of ways depending on the external environment including transportation, storage, and deployment.

To meet the fundamental needs of the stockpile, Sandia National Laboratories is changing the way surveillance will be done in the future. The program is called Integrated Stockpile Evaluation (ISE) and program is designed to integrate the knowledge collected on weapons systems during the stockpile life of a nuclear weapon. ISE will create an all-encompassing, predictive capability of stockpile issues so that the nuclear weapons enterprise will know what is coming with respect to each of the weapons in the stockpile. ISE will maximize our learning when a weapon is examined and tested. The information derived from modeling, simulation, and validation testing through both the science and engineering campaigns and laboratory-directed research and development research will be used to provide the ability to predict aging and other environmental changes to anticipate problems and fix them before they arise and weapons are unable to meet war reserve requirements. When changes are made to weapons, qualification, certification, product realization, and product acceptance data will be used to advance the ISE knowledge base. Information obtained from dismantlements will help develop aging signatures.



Developing a Consensus around RRW

The weapons concept of the future is labeled the reliable replacement warhead (RRW). Revolutionary in its vision, RRW is built around the simple but profound ideas that the Cold War is over, nuclear testing is likely gone forever, and nuclear weapons do not have to be designed at the edge of their design space.

USSTRATCOM

The end of the Cold war means the end of high yield to weight designs and all the design risk such a requirement embraces. The end of nuclear testing means that the design must be able to be qualified and certifiable with very high confidence in the absence of such testing. Weapons don't have to be designed near the edge of the design envelope and this means that restrictions on mass and volume can be exchanged for greater confidence, greater surety, and easier and cheaper manufacture.

USSTRATCOM, with its new mission responsibilities, looks at the missions to be covered by nuclear weapons in a very different way; they desire flexibility in the way nuclear weapons can and will cover their missions in the future. The services, the Navy and the Air Force, see the burden of nuclear weapons in their operationally impacts; the cost for security, the desire for dual capability in platforms, and the need to maintain control of the weapon right to the target and deny adversaries access to unused weapons under any circumstance. The RRW Concept will address and meet these requirements.

Path Forward for the Future of the Enterprise: Complex 2030

The stockpile of the future demands a complex of the future. A complex that utilizes the skills, capabilities, and facilities of today that can perform efficiently and effectively in the future and adds those needed pieces to provide responsiveness, cost-effectiveness, and sustainability for the enterprise. Key to the development of such an enterprise for the future is the ability to assess the performance, cost, and scheduling of every required process, program, and capability within it. In the past, Sandia had an essential role in the assessment of complex processes and programs. Since the end of the Cold War the role of system integrator has remained vacant and with the needed changes in the stockpile and complex and the challenges of skeptics within the administration and Congress it is essential that this important job be undertaken again.

Several high level panels, commissioned by either the administration or congress, have examined the nuclear weapons enterprise and found areas that need better management or programmatic change. The recent Secretary of Energy's Advisory Board report on the state of the complex for the future made a collection of recommendations to alter the goals, infrastructure, products, management structure, business practices, and incentives of the nuclear weapons complex. The NNSA has responded to these recommendations with a collection of their own. It is important that the execution of the program be enhanced and the correct path forward be defined for the nation's national security and maintenance of the nuclear deterrent.

FUTURE cont.

Sandia has created a Responsive Infrastructure Team to support the NNSA and its newly established Office of Transformation. NNSA leadership has developed a collection of responsive infrastructure goals that force on the rapid satisfaction changes to national security requirements. The Sandia team is working toward the development of a path forward for the complex as it transitions from its current state to the NNSA's 2030 vision.


Sandia


LLNL


Los Alamos

Pantex


Nevada Test Site


Kansas City Plant


Y-12


Savannah River

Summary

Although Sandia's nuclear weapons program has a collection of key challenges for the future, the vision and strategic direction is clear and the program shows significant promise. With over sixty of years of experience in the development and design of the non-nuclear components and sub-systems of the nation's nuclear stockpile, Sandia is poised to undertake the challenges and develop the answers to the needs of this critical segment of the nation's national security.

A new path for the future of the nuclear weapons program has been initiated through the SBET program. It is an underpinning for a new architecture for the weapons, a new way for surety, and a new process for stockpile evaluation. CASA will provide greater flexibility for weaponization design and integration. Integrated surety will provide a cheaper, more effective method of maintaining and enhancing the safety, security and use control of the United States deterrent. Using the full range of testing as signposts for discovering design birth defects and the effects of aging, the Integrated Stockpile Evaluation program will revolutionize stockpile assessment. Sandia is positioned to continue to be "America's Nuclear Weapons Engineering Laboratory".