LAWRENCE LIVERMORE NATIONAL LABORATORY'S ROLE AND CONTRIBUTIONS TO THE NUCLEAR SECURITY ENTERPRISE

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Committee on Armed Services
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OPENING REMARKS

Mr. Chairman and Members of the Subcommittee, I am William H. Goldstein, the Director of the Lawrence Livermore National Laboratory (LLNL). Thank you for the opportunity to provide my perspective on the President's FY 2015 Budget Request and governance of the Department of Energy/National Nuclear Security Administration's (DOE/NNSA) national security laboratories. I will also report on ongoing and future activities at LLNL in support of NNSA's Stockpile Stewardship Program (SSP) and our other important national security missions in the context of the budget proposal.

As one of the DOE/NNSA national security laboratories, LLNL is responsible for helping sustain the safety, security, and effectiveness of our nation's nuclear stockpile. A large part of that responsibility involves developing and maintaining the skilled workforce and broad set of capabilities and facilities that constitute a key component of the U.S. nuclear deterrent. Consistent with our mission, we also apply our capabilities to develop innovative solutions to important 21st-century national and global challenges.

This Subcommittee's continuing support of the SSP has helped enable us to sustain confidence in the nuclear weapons stockpile without nuclear testing. The successes of the SSP would not have been possible without these investments.

Stockpile Stewardship Program Challenges. The 2010 Nuclear Posture Review noted that "significantly increased investments" were required to "sustain a safe, secure, and effective nuclear arsenal as long as nuclear weapons exist." As our weapons age, we must strengthen the science, technology, and engineering base that underpins the U.S. nuclear stockpile and, when required, extend the life of warheads in accordance with national policy. The needs of the SSP include:

- *Stockpile Assessments.* While currently assessed to be safe, secure, and effective, stockpile warheads have aged well beyond their original design intent. Maintaining confidence in the stockpile requires a vigorous assessment program, subject to rigorous peer review, made up of both physical and enhanced surveillance, underpinned by NNSA's science, technology, engineering, and production capabilities. If Life-Extension Programs (LEPs) are prolonged or postponed, assessment tools and capabilities must be enhanced to address a growing set of issues, and to help guard against technical surprises.

- *Life-Extension Programs.* Because weapons in the stockpile continue to age beyond their intended service life, timely execution of planned LEPs is important. The LEP strategy supports the United States Strategic Command's "3+2" vision for the future stockpile (three future missile-delivered warheads and two future air-delivered weapons), endorsed by the Nuclear Weapons Council. Recent high-level decisions have resulted in a postponement of the ongoing W78/88-1 LEP, and the stretch-out of the incipient Long Range Stand-off (LRSO) LEP. These delays impact the needs of ongoing annual assessment activities and create challenges for workforce management.
- *Modernization of Facilities.* A healthy complex is a crucial component of the nation's nuclear deterrent capabilities, and provides a hedge against technological surprise and changing world conditions. Plans for modernization of two major capabilities are evolving because of budget constraints and will result in delays in their availability: the Uranium Processing Facility at the Y-12 National Security Complex, and modernized plutonium research and pit production capabilities at the Los Alamos National Laboratory (LANL). Other facilities are aging across the complex, leading to many smaller-scale but important infrastructure investment needs, including needs at LLNL.
- *The Science, Technology, and Engineering (ST&E) Base.* The ST&E capabilities at the NNSA laboratories are the foundation of the SSP. The people and their tools are needed for assessing and, where necessary, refurbishing our nuclear warheads. As the stockpile continues to age, and while LEPs and new production capabilities are delayed, our scientists and engineers face increased challenges in addressing the effects of aging on weapon safety, security, and effectiveness. We must continue to improve the ST&E capabilities that underpin the SSP.

In facing these challenges, LLNL remains focused on caring for the existing stockpile and sustaining or modernizing weapon systems consistent with national policy. To this end, we are strengthening the underpinning science, technology, and engineering of stockpile stewardship, and striving to maintain a responsive infrastructure, including innovative support to the NNSA production facilities. We are working to ensure that our workforce has the training and skills to meet current and future mission requirements. We are carefully considering cost-risk-benefit tradeoffs as we work on LEP warhead design options, to inform future LEP decisions. More generally, we continue to partner with NNSA and others in the complex to move the NNSA enterprise forward and offer innovative approaches to ensuring the effectiveness of our nuclear deterrent.

BUDGET PERSPECTIVE

Balancing investments across priorities is an enormous challenge. The nation cannot overfund one aspect of the SSP and put at risk others that are essential to long-term success. Fiscal constraints are stretching out the schedules for many SSP activities, investments, and deliverables. This increases program risk by leaving the complex potentially less prepared to deal with unanticipated technical problems, or a surprise brought on by the ever-evolving capabilities of adversaries. Resource constraints put a

premium on early identification of stockpile issues, which increases the pressure on our ST&E base.

In this regard, we have previously expressed concerns to this Subcommittee about the sufficiency of long-term ST&E and surveillance investments in the program needed to support annual assessment. Under the President's Budget Request for FY 2015, the prospect for LLNL is a modest, 4%, increase in funding relative to FY 2014 for core weapons activities. This is a welcome change after two years of significant budget decreases for two major reasons:

- *It provides needed capability improvements and program stability*. The proposed funding increases in Directed Stockpile Work (predominantly in Stockpile Systems and Stockpile Services) and the Science Campaigns (predominantly in Primary Assessments and Dynamic Material Properties) will enable us to improve our capabilities in support of current stockpile warheads (e.g., in improved material and component lifetime assessments and in addressing open Significant Findings), and continue the development of cost-aware LEP options. Benefits will include improved assessments of primary performance for aging, reconfigured, reused, and remanufactured pits; further exploration, development, and maturation of component technologies; and the development of more efficient methods for manufacturing.

  The LLNL staff has shrunk by about 30% since FY 2007 and nearly 15% over the last two years. This has stressed our depth of expertise in some areas as senior weapons experts have retired, and limited funding has constrained our ability to bring in and train the next generation of stockpile stewards. A stable program budget helps us ensure the succession of expertise necessary for long-term success in stockpile stewardship.

- *It provides a predictable path forward for National Ignition Facility (NIF) activities*. NIF is delivering data to support needed improvements in SSP predictive capabilities. Data from a range of experiments are being used to test and validate our simulation models and train our workforce. NIF has also recently achieved a key technical success on the path to ignition. Coupled with the progress we are making to improve the efficiency of NIF operations, level funding from FY 2014, as proposed in the FY 2015 President's Budget Request, for operations and experimental activities will allow researchers to effectively support the stockpile stewardship mission. At the requested funding level, we will continue providing essential data and make progress in FY 2015 toward understanding the requirements for achieving ignition and energy gain, which is important to understanding thermonuclear processes in weapons.

However, we have continuing concerns:

- *Work balance in stockpile stewardship—maintaining direct expertise in weapons development and engineering and supporting enhanced surveillance*. With the proposed budget, our work on the ST&E underpinning stockpile stewardship will increase, which is an important and a positive trend. At the same time, with the postponement of the W78/88-1 LEP and the delay in the first production unit date for the LRSO LEP, the opportunity for LLNL to exercise capabilities necessary for weapons development and engineering are impacted. Maintaining expertise in these areas will continue to be a challenge. We are also concerned about the continued

decrease in funding (both nationally and at LLNL) associated with enhanced surveillance. Enhanced surveillance (capabilities to predict and quantify potential future issues in stockpile warheads) is of growing importance to the Annual Assessment of the stockpile as current stockpile warheads continue to age.

- *Laboratory infrastructure***.** LLNL's infrastructure requires continual reinvestment to enable Laboratory staff to perform their important work for the nation efficiently, safely, and securely. LLNL successfully maintains required levels of readiness for its "mission critical" facilities and "mission dependent/not critical, enduring" facilities. However, the median age of facilities is 35 years and the most recent line-item facility construction project at LLNL was the Terascale Simulation Facility, begun in 2002. The deferred maintenance backlog is growing and three major mothballed facilities in deteriorating condition await funding for decontamination and demolition for proper risk reduction.

  I am pleased to report that several of our proposed line-item investments are on the NNSA's list of high priority items, including an Electrical Infrastructure Upgrade Project that addresses our highest assessed risk to future operations, and a new emergency response center. We are pleased that the FY 2015 budget request funds the emergency response center, but remain concerned that the Electrical Infrastructure Upgrade Project has been deferred for a second year. We are working with NNSA to ensure the earliest possible start for this project.

GOVERNANCE OF THE NNSA NATIONAL SECURITY LABORATORIES

We have consistently stressed to many audiences the importance of partnership and shared responsibility with NNSA to the successful execution of our vital national security mission. We stand ready to work with DOE, NNSA, and the Congress to turn ideas about a "more agile" relationship between NNSA and the national laboratories into actions. We have provided input to, and are actively listening, for the findings and recommendations of the Congressional Advisory Panel on the Governance of the Nuclear Enterprise, and the National Academy of Science Committee on Assessment of the Governance Structure of the NNSA National Security Laboratories, established by the National Defense Authorization Act for FY 2013. The initial finding of the first panel that there has been a "loss of sustained national leadership focus" is strong motivation to quickly determine a path forward. We are eager to contribute constructively to the deliberations that will surely follow the issuance of the panel's recommendations.

STOCKPILE STEWARDSHIP PROGRAM ACCOMPLISHMENTS

FY 2013 and the beginning of FY 2014 have seen many significant accomplishments in assessing and sustaining the nation's nuclear weapons stockpile and applying and strengthening the underpinning ST&E. Our work was carried out through partnerships and at sites across the NNSA complex. Over the last year, we have:

- *Completed Cycle 18 of the Annual Assessment of the stockpile*. Continuing efforts at LLNL increased the rigor of the assessment process through extensive peer review that included the Independent Nuclear Weapon Assessment Process, and the

application of improvements in predictive capabilities. During the last year, we also reduced surveillance backlogs and expeditiously addressed significant findings.

- *Completed key LEP tasks*. We identified a cost-informed preferred design concept and down-select of the pit and nuclear explosive package for the W78/W88-1 LEP (now on a five-year hold). The selected design meets all military threshold requirements and enables achievement of enhanced surety. In addition, warhead options for further evaluation in Phase 6.1 were identified for the LRSO weapon.
- *Attained important results at NIF to support the SSP*. NIF high-energy-density physics shots are providing valuable data about the properties of materials at extreme conditions, the interaction of matter with intense radiation, and hydrodynamic turbulence and mixing of materials. Experiments to develop an improved understanding of the underlying physics for achieving ignition produced more energy through "self heating" from fusion reactions than was delivered into the fusion fuel. Altogether 158 shots were fired on NIF in FY 2013 to support the SSP. Diagnostics and support capabilities have grown considerably to meet user demand, and the NIF team is continuously improving the efficiency of operations.
- *Brought the 20-petaflops (quadrillion floating point operations per second) Sequoia supercomputer into classified operation*. Operating as a tri-laboratory resource, Sequoia enables the use of higher-fidelity physics models in simulations and makes it possible to run large suites of simulations for estimating the sources of uncertainty that affect weapon safety and performance. In addition, NNSA reached a key step (Critical Decision-0) toward acquisition of the next major computer platform to be deployed at LLNL through CORAL (Collaboration of Oak Ridge, Argonne, and Lawrence Livermore). CORAL aims to achieve important technological advances needed by the SSP for predictive capability and 3D uncertainty quantification.
- *Conducted a wide range of highly successful SSP experiments*. Laboratory scientists designed and fielded experiments at facilities at Livermore, Los Alamos, Sandia, the University of Rochester, and the Nevada National Security Site and gathered data to improve our understanding of weapons physics and support LEPs. For example, we tested an innovative concept for pit reuse in a highly successful hydrodynamic test at LLNL's Contained Firing Facility.
- *Engaged in developing new additive manufacturing (AM) processing technologies*. Providing capabilities far beyond current state-of-the-art commercial tools, these new AM technologies are able to create features and architectures at the micro- and even nano-scale to make materials with previously unachievable properties (e.g., ultra-lightweight structural materials). Working with partners within the NNSA complex, we are exploring the potential role for this technology in support of the SSP.

MEETING BROADER NATONAL SECURITY NEEDS

Since the Laboratory's founding in 1952, Livermore researchers have applied their capabilities to develop innovative technical solutions to help meet pressing national and global security needs. The work has grown in importance as the country faces an expanding list of complex national security issues in the 21st century, for which solutions demand scientific and technology innovation. Research and development projects at

LLNL support the U.S. military, counter chemical and biological threats, and enhance cyber, aviation, and infrastructure security. We help in areas that take full advantage of LLNL's unique research capabilities, special expertise, and our multidisciplinary teaming approach to problem solving.

Work for NNSA on nuclear nonproliferation and counterterrorism, for the DOE's Office of Science and energy technology offices, other federal agencies, and other sponsors, not only meets their important needs but serves to sustain the long-term health and vitality of LLNL. These efforts extend existing core competencies and build new strengths in multidisciplinary ST&E, which in turn, benefit the stockpile stewardship mission and national security. Notable activities in FY 2013-14 include:

- *Emergency response.* LLNL's National Atmospheric Release Advisory Center (NARAC) provides predictions of the impacts of hazardous atmospheric releases to emergency managers and responders. Each year, NARAC typically responds to 10,000 airborne-plume simulation requests for emergency preparedness, participates in 100 major emergency response exercises, and responds to 25 incidents, including major events such as the Fukushima Dai-ichi nuclear power plant accident.
- *Radiation detection.* Customs and Border Patrol is piloting LLNL's new Enhanced Radiological Nuclear Inspection and Evaluation (ERNIE) software that will improve the sensitivity of radiation portal monitors to provide high levels of nuclear security while also reducing the high false alarm rate that can interfere with traffic volumes at monitoring stations.
- *Foreign nuclear weapons analysis.* LLNL provides accurate, comprehensive, and timely assessments of the nuclear weapon capabilities of countries of concern. Our analysis contributes to decision-making at the highest levels, including National Intelligence Estimates (NIEs). We also develop technologies and systems to help the Intelligence Community meet its data collection and information exploitation needs.
- *Cyber security.* LLNL is expanding the application of cyber security capabilities that are able to provide real-time situational awareness inside a large computer network by using a distributed approach to monitoring for anomalous behavior. Through our Network Security Innovation Center, we work with private partners to counter the constant attack on commercial, infrastructure, and national security networks.
- *Tracking space debris*. The national security community is proposing to use nano-satellites with LLNL-developed optical system for tracking space debris. A constellation of such nano-satellites is projected to be able to track pieces of space debris with a precision ten times greater than currently possible, which would greatly reduce the false alarm rate for possible collisions with U.S. satellites.
- *Nuclear forensics.* LLNL's Nuclear Forensics program is beginning to use the capabilities of NIF to produce fission products needed for more realistic forensic exercises. The samples are used in round-robin exercises that ensure the nation's nuclear debris diagnostic capabilities are maintained in a constant state of readiness.
- *Advanced conventional munitions.* The BLU-129/B low-collateral-damage munition, developed from concept to delivery to the combatant commander in only 18 months, recently won the 18th annual William J. Perry Award, and we completed a highly

successful hypersonic sled test of an advanced kinetic energy warhead in 2013.

- *Support for the U.S. military.* The Laboratory's Counterproliferation Analysis and Planning System (CAPS), a tool to assist in planning missions against facilities that potentially support WMD production, was used scores of times in the past year to provide technical assistance to combatant commanders and to U.S. troops in the field. We also support DOD's mission to detect and defeat improvised explosive devices.
- *Countering biological threats.* LLNL developed and licensed a technology to safely validate the performance of biodetection systems designed to provide early warning of aerosol releases of biological agents. Our cutting-edge detection technologies support the needs of the recently released "National Strategy for Biosurveillance."
- *Aviation security.* To better protect against the threat of homemade explosives to commercial air transportation, LLNL provides the Department of Homeland Security with expertise and extensive facilities for explosive testing and evaluation.

WORKFORCE RECRUITMENT AND DEVELOPMENT

To sustain the Laboratory's expertise in nuclear weapon design and cultivate its spirit of innovation, LLNL endeavors to attract a world-class workforce by providing the opportunity to serve the nation working on exciting projects, with outstanding colleagues, and state-of-the-art research capabilities. Many prospective career employees first come to the Laboratory as postdoctoral fellows to work on cutting-edge ST&E, often funded by Laboratory Directed Research and Development (LDRD). LDRD is exceedingly effective for workforce development, and, in many cases, it is the only means by which we explore innovative approaches to meet emerging national needs before they are sufficiently demonstrated to attract sponsor funding.

Recruitment and employee development at LLNL has been challenged in recent years as weapons-related funding has decreased. The program stability offered in the FY 2015 Budget Request greatly helps the Laboratory in workforce planning and recruiting. Fortunately, we continue to attract outstanding young people. For example, in the four years of the program, the extremely competitive DOE Office of Science (SC) Early Career Research Program has made awards to ten LLNL researchers. Only two DOE laboratories have more awards.

LLNL provides an extensive range of employee development, mentoring, and leadership training programs to foster career growth. Special attention is being devoted to identifying and meeting needs for critical skills and to succession planning. Succession plans are being developed across the Laboratory and used to inform nominations for advancement and leadership development programs.

CLOSING REMARKS

I thank the Subcommittee for its continuing support of the SSP, and the dedicated men and women of LLNL, who are committed to making our nation more secure through

advances in ST&E. We greatly appreciate the attention the SSP is receiving, but the challenges confronting the program and its investment needs are substantial.

In the face of these challenges, LLNL remains focused on caring for the existing stockpile and modernizing or sustaining weapon systems consistent with national policy. The prospect for LLNL under the President's Budget Request for FY 2015 is a modest increase in funding for weapons activities. This reverses the trend of recent years, and will help us strengthen the SSP's underpinning ST&E, maintain a responsive infrastructure, and develop cost-informed options for LEPs.

We must ensure that our workforce continues to have the training and skills necessary to meet current and future mission requirements. As long as there are nuclear dangers in the world, a cadre of talented scientists and engineers dedicated to national service and with the necessary skills, training, and tools, will be needed to sustain the nuclear stockpile without testing. In this regard, I am concerned about the delay of work on LEPs at LLNL, which limits opportunities to exercise weapons development and engineering expertise. In addition, as LEPs are prolonged or postponed, the pressure increases on SSP assessment tools and capabilities as they address a growing set of issues and protect against technical surprise.

With sustained support for the SSP—and for complementary work as a broad-based national security laboratory—LLNL will continue to help ensure a safe, secure, and effective nuclear weapons stockpile, and develop innovative solutions challenges in nuclear security, international and domestic security, and energy and environmental security.

Thank you for this opportunity to address the Subcommittee.

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Dr. William H. Goldstein was named the twelfth Director of the Lawrence Livermore National Laboratory (LLNL), on March 31, 2014. He is responsible for the management of the Laboratory and also serves as the President of Lawrence Livermore National Security (LLNS), LLC. As the Director, he is committed to carrying on a tradition of scientific and technical excellence in service to the Nation.

Dr. Goldstein has most recently served as Deputy Director for Science and Technology (DDST) at LLNL, where he led the strategic deployment of the Laboratory's portfolio of world-class science, technology, and engineering (ST&E) capabilities and managed the long-term health of ST&E at the Laboratory. He had line responsibility for the Laboratory's internal ST&E investment portfolio, which includes the Laboratory Directed Research and Development (LDRD) Program, and oversaw collaborative research with academia and private industry, and institutional planning activities. Between 2001 and 2012, as Associate Director, Dr. Goldstein led the Laboratory's Physics and Advanced Technologies Directorate which later became the Physical and Life Sciences Directorate, performing research in condensed matter and materials science, chemical and biological science, atmospheric and earth systems science, high energy density physics, nuclear science, and high energy physics, in support of LLNL's energy, nuclear, and international security missions. Dr. Goldstein has been a leader in the establishment and management of the Department of Energy's stockpile stewardship program. He formulated and initially led LLNL's Physical Data Research Program, with responsibility for providing experimentally validated equations-of-state, material properties, opacities, and nuclear cross section and transport data for nuclear design.

Dr. Goldstein's main research interests have been in computational modeling of highly charged ions, atomic spectroscopy, and radiative processes in plasmas. His work has significantly advanced the understanding of high energy density plasma properties through spectral modeling, and has been applied in x-ray laser, high-energy astrophysics, and fusion energy research. Dr. Goldstein co-authored the concept of atomic "super transition arrays (STA)," a major advance in the simulation of heavy element opacity and plasma kinetics. He helped develop the first spectroscopic diagnostics for astrophysical photo-ionized plasmas and designed some of the earliest laboratory astrophysics experiments using high-power lasers. Goldstein led the application of atomic modeling and the STA method to problems in the Department of Energy's nuclear-pumped x-ray laser, weapons physics, and ICF programs that resolved a series of scientific problems.

Dr. Goldstein received his Ph.D. in theoretical physics from Columbia University in 1983, for work on symmetry breaking in models with composite quarks and leptons. As a postdoctoral fellow at the Stanford Linear Accelerator Center (SLAC), he studied magnetic monopoles before joining LLNL in 1985. Dr. Goldstein received a DOE Weapons Recognition of Excellence Award in 1994 and he became an AAAS Fellow in 2009.