N1

Office of the President

TO MEMBERS OF THE NATIONAL LABORATORIES SUBCOMMITTEE:

DISCUSSION ITEM

For Meeting of November 16, 2016

NATIONAL LABORATORIES UPDATE AND PRESENTATION ON THE STATE OF THE LAWRENCE LIVERMORE NATIONAL LABORATORY

The discussion will provide an update on the activities of the three University of California-affiliated Department of Energy (DOE) National Laboratories, Lawrence Berkeley National Laboratory (LBNL), Lawrence Livermore National Laboratory (LLNL), and Los Alamos National Laboratory (LANL), followed by a presention by LLNL Director William Goldstein on the state of the LLNL.

Lawrence Livermore National Laboratory

State of the Lab Presentation: Lawrence Livermore National Laboratory – The New Ideas Laboratory

LLNL Director William Goldstein will provide a presentation entitled "Lawrence Livermore National Laboratory – The New Ideas Laboratory."

The 21st century presents a serious and ever-growing set of national security challenges in need of innovative solutions. For almost 65 years, LLNL has been entrusted with providing the science, technology, and engineering expertise necessary to design, test, and now steward the nuclear weapons stockpile. That responsibility has been extended to broader aspects of national security, including chemical and biological security, cybersecurity, energy security, and countering forms of terrorism. Equally important, LLNL is frequently called upon to provide expert analyses and judgment on the technical capabilities of known and suspected adversaries of the U.S. and its allies.

Providing solutions to this "problem set" of challenges forms the day-to-day focus of LLNL's outstanding workforce and defines its primary mission: innovation to enhance the nation's security. The responsibility is not taken lightly because of the potential influence this Laboratory has on national and international assessments and decisions. Innovative thinking, underpinned by strong science, technology, and engineering, is at the core of our success. LLNL's multi-disciplinary team approach to problem-solving, freedom to express ideas and opinions instilled and fostered through its six-plus decades' association with the University of California, world-

class facilities, and a mission-first culture all provide the strong basis from which to deliver on LLNL's mission.

Capabilities and products developed for national security applications often have relevance and impact in other areas, such as the health sciences. UC has been a strong, ever-present partner and collaborator in many of these "dual use" applications. Just as importantly, the UC campuses provide a steady flow of scientists and engineers, both as students and staff, to the Laboratory. This enduring relationship provides LLNL expertise and knowledge that is crucial to realizing its mission, and instills an environment that strongly values learning and teaching. The close association between UC and LLNL also enhances LLNL's credibility with stakeholders around the world.

A brief overview of the Laboratory's mission areas will be provided. Highlights will include LLNL's role and the activities surrounding the Joint Comprehensive Plan of Action with Iran as well as recent efforts in promoting DOE National Laboratory expertise in high-performance computing to aid in the National Strategic Computing Initiative and the President's Cancer Moonshot Initiative.

Lawrence Berkeley National Laboratory

Advanced Light Source Upgrade Project Receives First DOE Approval

The proposed Advanced Light Source Upgrade project (ALS-U) has cleared the first step in the DOE approval process. On September 27 it received "critical decision zero," also known as CD-0, which approves the scientific need for the project. This initial step sets in motion a process of additional planning and reviews, and the Laboratory will begin the upgrade's conceptual design.

If ultimately advanced, the ALS-U would feature a new, circular array of powerful, compact magnets. This state-of-the-art array, known as a "multibend achromat lattice," and other improvements would allow the ALS to achieve far brighter, steadier beams of so-called "soft" or low-energy X-ray light, enabling new explorations of chemical reactions, battery performance, biological processes, and exotic materials.

ALS-U would utilize and preserve the existing ALS building, an iconic domed structure designed in the 1930s by Arthur Brown Jr., the architect who also designed Coit Tower, a San Francisco landmark.

The ALS dome was originally built in the 1940s to house an early particle accelerator known as the 184-inch cyclotron, a brainchild of Berkeley Lab founder Ernest O. Lawrence. Construction to convert the facility into the ALS began in 1988 and was completed in 1993. The ALS has undergone several improvements since startup – the latest was a four-year brightness improvement project, completed in 2013 and which recently received the Energy Secretary's Achievement Award, that as much as tripled the brightness of X-ray light at some of its beamlines.

ALS-U represents the largest new project at the lab since the ALS was completed, and takes advantage of a more than half-billion-dollar investment in the existing ALS. The next stage of DOE project review and approval, known as CD-1, would confirm site selection for the proposed transformational soft-X-ray synchrotron project.

About 200 scientific and engineering staff work at the ALS, which draws thousands of scientific "users" per year from around the world. In fiscal year 2015, the ALS hosted more than 2,500 of these visiting scientists from 43 U.S. states and Washington, D.C., and 33 other nations. In collaboration with ALS staff experts, these scientists produce more than 900 peer-reviewed articles per year featuring work performed at the ALS.

Los Alamos National Laboratory

PF-4 Resumes Operations and Is Toured by Defense Secretary Carter

In late September, the LANL Plutonium Facility (PF-4) returned to full operations following a pause of more than two years in the facility's fissile material operations.

PF-4 is the nation's only fully capable plutonium research and processing facility. Fissile material operations were suspended in June 2013 because of criticality safety issues. A DOE review released in January found LANL had made significant improvements toward fully resuming operations, including in its execution of procedures, criticality safety postings, fissile material labeling, and worker training and qualification. LANL has implemented new criticality safety controls at the facility as part of its sitewide nuclear criticality safety program, which aims to prevent inadvertent nuclear criticalities, or self-sustaining nuclear fission chain reactions.

Defense Secretary Ash Carter's late September visited to LANL included a half-day tour of PF-4. Secretary Carter observed the resumed operations at the pit casting area of the facility, where molten plutonium is molded and shaped.

SCIENCE HIGHLIGHTS

UC-affiliated National Laboratories Honored with American Physical Society Awards

In October, the American Physical Society (APS) has announced its Spring 2017 prize and award winners. APS prizes and awards are generally open to all members of the scientific community in the U.S. and abroad. These honors are highly regarded, and represent critical recognition from the recipients' most discerning audience, their peers.

Winners of the Spring 2017 APS Prizes and Awards include:

Herman Feshbach Prize in Theoretical Nuclear Physics:
Joseph Carlson (*Los Alamos National Laboratory*)
For pioneering the development of quantum Monte Carlo techniques to solve key problems in nuclear structure physics, cold atom physics, and dense matter theory of relevance to neutron stars.

Max Delbruck Prize in Biological Physics:
Alan Perelson (*Los Alamos National Laboratory*)
For profound contributions to theoretical immunology, which bring insight and save lives.

Davisson-Germer Prize in Atomic or Surface Physics:
Eli Rotenberg (*Lawrence Berkeley National Laboratory*)
For the development of angle-resolved photoemission spectroscopy leading to groundbreaking surface science.

Excellence in Physics Education Award:
Contemporary Physics Education Project (Howard Matis) (*Lawrence Berkeley National Laboratory*)
For leadership in providing educational materials on contemporary physics topics to students for more than 25 years.

Joseph F. Keithley Award for Advances in Measurement Science:
Peter Denes (*Lawrence Berkeley National Laboratory*)
For his pioneering advances in detectors for electron and X-ray microscopy, especially the development of complementary metal oxide semiconductor detectors for electron microscopy, and column parallel readout charge coupled devices for ptychographic X-ray microscope.

Earlier in the year, LLNL's Tammy Ma won the 2016 APS Thomas H. Stix Award for Outstanding Early Career Contributions to Plasma Physics Research. The award citation recognizes Ma for "innovation and leadership in quantifying hydrodynamic instability mix in Inertial Confinement Fusion implosions on the National Ignition Facility and for key contributions to experiments demonstrating fusion fuel gains exceeding unity." Ma was also recently awarded the Presidential Early Career Award for Science and Engineering, the highest honor bestowed by the United States government on science and engineering professionals in the early stages of their independent research careers.

Remi Lehe of LBNL also won the 2016 APS Nicholas Metropolis Award for Outstanding Doctoral Thesis Work in Computational Physics, for the development, implementation, and application of new algorithms toward the improvement of laser-wakefield accelerators.

UC-affiliated National Laboratories Dominate List of R&D 100 Award Finalists

In September, the finalists were announced for the 54th annual R&D 100 Awards, which honor the 100 most innovative technologies and services of the past year and are often referred to as the "Oscars of Invention," Award recipients were announced in early November.

The research projects announced as finalists for the 2016 R&D 100 Awards are as follows, with recipients identified by an asterisk:

LLNL

***GLO Transparent Ceramic Scintillator** dramatically increases high-energy, or mega-electron-volt, radiography throughput by providing seven times faster imaging than glass

scintillators and decreases the X-ray dose required to obtain detailed imagery. Mega-electron-volt radiography is used to nondestructively image the 3D volume of complex objects.

***Polyelectrolyte Enabled Liftoff (PEEL)** is a robust, scalable method of fabricating freestanding polymer films that are larger, stronger, and thinner than what conventional methods can produce. PEEL is used at the National Ignition Facility for the daily fabrication of membranes as thin as 30 nanometers that serve as compliant, load-bearing elements for laser targets. Because the process is easily scalable in size and manufacturing quantity, it could be applied to sensing, catalysis, filtration, and wound-healing applications.

Solution-grown Crystals for High-Energy Neutron Detection is a method for growing large-scale, economical stilbene crystals capable of efficiently distinguishing neutrons from gamma rays without the toxicity, flammability, and handling difficulties that commercial liquid scintillators present. Detecting and distinguishing between neutrons and gamma rays are critical to identifying nuclear substances such as uranium and differentiating them from benign radioactive sources.

***Carbon Capture Simulation Initiative (CCSI)** is a toolkit that consists of a suite of computational tools and models to accelerate the development of carbon capture technology for manufacturers and businesses. Launched in 2011 and now in its fourth generation, the CCSI's objectives are to develop, demonstrate, and deploy advanced computational tools and validated multi-scale, multi-physics models. Its mission is to reduce the risk and time required to develop and scale up new carbon capture and related chemical process technologies. It has been developed by five universities and five national laboratories including LLNL, LBNL, and LANL.

LANL

***Entropy Engine** is a random number generator that addresses a key fundamental flaw in modern crypto systems predictability. The invention strengthens the foundation of computer security by producing an inexhaustible supply of pure random numbers at speeds of 200 million bits per second. Entropy Engine uses the unique properties of quantum mechanics to generate true entropy (random numbers) in a way that makes it immune from all external influences.

Hybrid Optimization Software Suite provides a simulation platform to conduct “virtual experiments” that help model and analyze materials phenomena that cannot be readily produced or studied in a laboratory or real-world setting. It is the first to combine finite-element and discrete-element methods with an all-regime computational fluid dynamics solver to generate accurate simulations of complex multi-physics problems, such as material deformation, fracture, and failure analyses.

MarFS is a thin software layer written specifically to leverage cloud storage technology for high-performance parallel cold data storage. The software maps directories and files in legacy systems, including those used by companies that handle vast amounts of data, to cloud-based

object storage. MarFS is so flexible that it can adapt to new storage technologies as they are developed.

***PathScan** provides security analytics for computer network attack detection. Traditional computer network security tools, which search for malware or network signatures, insufficiently protect from expensive data breaches. Traditional defense mechanisms – perimeter controls and end-point antivirus protection – cannot keep pace with these increasingly innovative and sophisticated adversaries. Rather than detecting something that "looks" like a cyberthreat, PathScan searches for anomalous communications behavior within the network. It performs a statistical analysis of abnormal behavior across a network and identifies the lateral, reconnaissance, and data staging behaviors of attackers.

Photonic Band Gap Structures enable a new generation of high-current, high-power accelerators. Today, there are more than 30,000 particle accelerators operating around the world for use in basic science and applications in medicine, energy, environment, national security, and defense. These accelerators use electromagnetic fields to propel charged particles to nearly the speed of light, containing the particles in well-defined beams. The photonic band gap structures improve the quality and intensity of the beams.

***Pulmonary Lung Model (PuLMo)** is a miniature, tissue-engineered lung developed to revolutionize the screening of new drugs or toxic agents. Current screening methods may not accurately predict response in humans. PuLMo also could be used as a platform to study the flow dynamics of particles inside a lung for applications in drug delivery and particle/pathogen deposition studies. PuLMo has the potential to enable screening of new drugs more effectively by improving the reliability of pre-clinical testing and saving time, money, and lives.

***Quantum Dot Solar Windows**. These revolutionary semitransparent windows contain highly emissive semiconductor nanocrystals (quantum dots) that collect sunlight for photovoltaics and provide a desired degree of shading. The material can turn windows and building facades into electrical generators of nonpolluting power. The nontoxic dots absorb the sunlight, re-emit it at a longer wavelength and waveguide it towards edge-installed photovoltaic cells to produce electricity. This technology can transform once-passive building facades into power-generation units, which can be particularly useful in densely populated areas.

***Virtual Environment for Reactor Applications** bridges the gap between research and engineering by bringing together a suite of coupled software applications that simulate the performance of commercial light water reactors. This toolkit allows systems and process to be engineered to higher levels of of performance with longer and more productive lifetimes.

LBNL

Shifter is a customized software package for deploying containers and user-defined images in high-performance computing (HPC) systems. It was developed at the National Energy Research Scientific Computing Center (NERSC) to improve flexibility and usability of its systems for increasingly data-intensive workloads. It is initially being tested on NERSC's Edison system by

users in particle physics and nuclear physics and will eventually be made available as an open-source tool for the general HPC community.

***Cool Roof Time Machine** is a method to simulate soiling and weathering processes in the laboratory, reproducing in only a few days the solar reflectance of roofing products naturally aged for three years.

***Sustainable and Affordable Fluoride Removal** is a low-cost method for using mildly-processed bauxite, a readily available aluminum-rich ore, to remediate fluoride concentrations in drinking water. Two hundred million people worldwide are at risk of developing irreversible crippling deformities (e.g., dental/skeletal fluorosis) by drinking water contaminated with toxic levels of naturally-occurring fluoride.

Distributed Energy Resources Customer Adoption Model Plus (DER-CAM+) is an advanced decision-support tool for optimizing investment capacities, placement, and dispatch of distributed energy resources. Unlike previous versions of DER-CAM, which have been under development at LBNL since 2000, DER-CAM+ has been tailored for microgrid applications.

Grid Burner is an open-flame cooking burner that provides enhanced cooking, improved efficiency, fuel savings, and reduced air pollutant emissions.

Compact Diode Beamstop is a compact, customizable tool for X-ray scattering experiments providing real-time data. This tool will enhance X-ray beamlines used for research in potentially life-enhancing and lifesaving discoveries in material, medical, and biological sciences.

***Polymers of Intrinsic Microporosity (PIM) Membrane for Long-Lived Li-S Batteries** is a low-cost, easily processed polymer membrane enabling next-generation lithium-sulfur batteries with enhanced lifetimes and energy efficiency.

Key to Acronyms

ALS	Advanced Light Source
ALS-U	Advanced Light Source Upgrade
APS	American Physical Society
CCSI	Carbon Capture Simulation Initiative
DER-CAM+	Distributed Energy Resources Customer Adoption Model Plus
DOE	Department of Energy
HPC	High-Performance Computing
LANL	Los Alamos National Laboratory
LANS	Los Alamos National Security, LLC
LBNL	Lawrence Berkeley National Laboratory
LLNL	Lawrence Livermore National Laboratory
LLNS	Lawrence Livermore National Security, LLC
NERSC	National Energy Research Scientific Computing Center
PEEL	Polyelectrolyte Enabled Liftoff
PF-4	Plutonium Facility
PIM	Polymers of Intrinsic Microporosity
PuLMo	Pulmonary Lung Model