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Chairman Upton, Ranking Member Rush, and members of the Committee: Thank you for the opportunity to appear before you today. It is an honor to provide this testimony on the U.S. Department of Energy (DOE) and the role of the DOE national laboratories in executing the Department's missions.

INTRODUCTION

My name is Thomas Zacharia, and I am Director of Oak Ridge National Laboratory (ORNL) in Oak Ridge, Tennessee. I am also a member of the National Laboratory Directors Council (NLDC), an organization formed by the directors of the 17 DOE labs. In my previous position as ORNL Deputy for Science and Technology, I was a member of the NLDC Chief Research Officers Working Group, which advises DOE senior leadership and the NLDC on scientific, programmatic, and operational issues at the national laboratories.

While I am speaking today on my own behalf, my participation in these groups has provided me with a perspective on the national laboratories that extends beyond ORNL. That perspective informs my views on the topics that you are considering today.

I will begin with an overview of ORNL and its programs in science, energy, and national security and provide some examples of how the national laboratories support the execution of DOE's missions in these vital areas. I will briefly discuss the governance of the national laboratories, and I will describe actions that DOE is taking in partnership with the contractors who manage and operate these laboratories to implement regulatory and policy reforms that are designed to make the national laboratories as efficient and effective as possible.

OVERVIEW OF ORNL

ORNL is DOE's largest science and energy laboratory, with a research and development (R&D) portfolio that spans the range from fundamental science to demonstration and deployment of breakthrough technologies for clean energy and national security. Our mission explicitly includes both scientific discovery and innovation, so we place a high value on translational R&D—the coordination of our basic research and applied technology programs to accelerate the deployment of solutions to compelling national problems.

In fiscal year (FY) 2017, ORNL's budget was $1.65 billion. Most of our funding comes from various elements of DOE, including the Office of Science (SC), the Office of Energy Efficiency and Renewable Energy (EERE), the Office of Nuclear Energy (NE), and the National Nuclear Security Administration (NNSA). In any given year, however, 15 to 25 percent of our funding

comes from other federal agencies, state and local governments, and private-sector customers. Our major non-DOE sponsors include the U.S. Department of Defense, the U.S. Department of Homeland Security, the Nuclear Regulatory Commission, the National Aeronautics and Space Administration (NASA), and the U.S. Department of Veterans Affairs. Our work for these sponsors both exploits and strengthens our unique core capabilities.

The distribution of our funding across DOE's major mission areas is roughly 60 percent to science programs, 20 percent to clean energy programs (including nuclear), and 20 percent to national security programs, but it is important to recognize that R&D often has impacts on more than one mission area. In addition, our focus on translational R&D means that we place considerable emphasis on the integration of basic and applied research, often drawing on our distinctive research facilities and on our ability to quickly assemble and deploy multidisciplinary teams to focus on compelling problems.

To illustrate this point, I need to give you some background on ORNL's capabilities. We host four SC user facilities: the Spallation Neutron Source (SNS); the High Flux Isotope Reactor; the Center for Nanophase Materials Sciences; and the Oak Ridge Leadership Computing Facility (OLCF). We also host four shared R&D facilities supported by EERE: the Building Technologies Research and Integration Center, the Carbon Fiber Technology Facility, the Manufacturing Demonstration Facility (MDF), and the National Transportation Research Center (NTRC). Access to ORNL's nuclear and radiological facilities is provided through NE's Nuclear Science User Facilities (NSUF) and the NE Gateway for Accelerated Innovation in Nuclear (GAIN) program.

Substantial value results from the co-location of these resources with one another and with R&D programs that both draw on them and drive their development. For example, with support from EERE, researchers at ORNL have worked with researchers at DOE's Ames Laboratory, NNSA's Lawrence Livermore National Laboratory, and a Wisconsin company, Eck Industries, to develop a new high-performance aluminum alloy. The automotive industry is interested in aluminum alloys that can operate at high temperatures because of their potential for use in lightweight engine components, which would increase efficiency and fuel economy. To assess the performance of their new alloy under real-world operating conditions, the research team used the resources of MDF and NTRC to cast a cylinder head made of this alloy, using sand molds created by 3D printing. They retrofitted this component to a gasoline-powered engine designed to operate on the VULCAN instrument at SNS and used neutron diffraction to assess the performance of the running engine. This experiment confirmed that the new alloy outperforms other aluminum alloys under realistic operating conditions. It also demonstrated the benefits of coupling fundamental science with early-stage R&D on new materials and technologies.

Another ORNL-led partnership links DOE national laboratories, universities, and industry in a multiyear effort to confidently predict the performance of existing and next-generation commercial nuclear reactors through comprehensive, science-based modeling and simulation. Founded in 2010, the Consortium for Advanced Simulation of Light Water Reactors (CASL) takes advantage of the OLCF and of ORNL's exceptional strengths in nuclear science and engineering. It also draws on the resources of a formidable set of core partners: three national laboratories (NE's Idaho National Laboratory and NNSA's Los Alamos National Laboratory and Sandia National Laboratories), three research universities with strong nuclear engineering

programs (the Massachusetts Institute of Technology, North Carolina State University, and the University of Michigan), and three partners from the nuclear power industry (the Electric Power Research Institute, the Tennessee Valley Authority, and Westinghouse). CASL has connected fundamental research and technology development to develop VERA, a Virtual Environment for Reactor Applications that can simulate the operation of a nuclear power plant. When the Tennessee Valley Authority started up its Watts Bar Unit 2 reactor in 2016, VERA was used to perform hour-by-hour simulations of the new plant's first six months, with predictions providing important data to support the achievement of full-power operations. Westinghouse has used VERA to simulate the startup of its new AP1000 pressurized water reactor, confirming its engineering calculations.

To give you an example relating to national security: ORNL researchers have exploited the Laboratory's extensive capabilities to develop tools and technologies for protecting the nation's electric grid from cyber and physical threats. These resources range from hardware in the form of monitoring devices to software that can detect malicious code to platforms that can detect the presence of advanced persistent threats. In developing these innovations, we have drawn on a long history of discovery and innovations in power and energy systems and in the development and assessment of technology for protecting critical infrastructure. We have also applied our recently developed expertise in advanced manufacturing to create low-cost, 3D-printed sensors that can identify voltage issues and power failures as soon as they occur, while also fusing performance analysis with weather and climate indicators, thus supporting more efficient and cost-effective grid security, maintenance, and disaster response. We work closely with industry partners, including the Chattanooga Electric Power Board, Dominion, Duke Energy, Southern

Company, and the Tennessee Valley Authority, to test and deploy innovations in grid modernization and security. ORNL is also part of the Grid Modernization Laboratory Consortium (GMLC), a strategic partnership between DOE and 13 national laboratories that is working closely with partners in industry and academia across multiple cities and states. One of our GMLC projects, the Southeast Consortium, is establishing a regional partnership to increase utility clean energy portfolios and improve power system network resiliency, with the goal of ensuring both increased reliability and improved responsiveness under extreme conditions by eliminating outages or enabling faster restoration of power to critical loads. Our partners on this project include DOE's Savannah River National Laboratory and three universities in the region: the University of Tennessee, the University of North Carolina at Charlotte, and Clemson University.

The DOE national laboratories also work together to deliver the tools needed to accomplish the Department's missions. Earlier, I mentioned the OLCF, which is one of two DOE leadership-class computing facilities. The national laboratories have worked with industry for decades to build powerful supercomputers and apply them to DOE mission needs. These HPC systems have delivered nuclear weapons simulation and modeling capabilities that are vital to the NNSA's Science-Based Stockpile Stewardship Program. They have been used by scientists to understand the evolution of stars, to simulate the combustion of alternative fuels in high-performance engines, to accelerate drug design and discovery, and to improve our understanding of the hazards and risks of earthquakes. Researchers from industry have exploited them to design advanced aircraft, high-efficiency gas turbines, and better paper products. Finally, the technologies developed to enable these systems are exploited by industry to bring ever more

powerful devices to the marketplace. (To quote Lewis Platt, CEO of Hewlett-Packard in the 1990s, "Yesterday's supercomputer is today's laptop.")

In the past few years, other nations—notably China—have invested heavily in the development of HPC systems. As of November 2017, China's TaihuLight system was more than five times as powerful as the top-ranked U.S. system, the Cray XK7 Titan at ORNL. The DOE national laboratories are actively engaged in reclaiming U.S. leadership in this vital area. At the OLCF, we are deploying a system that may well be the world's most powerful supercomputer when it begins operating later this year. Summit will be at least five times as powerful as Titan. It will also be an exceptional resource for deep learning, with the potential to address challenging data analytics problems in a number of scientific domains. Summit is among the products of CORAL, the Collaboration of Oak Ridge, Argonne, and Livermore, a partnership that was recognized by *HPCWire* in 2015 with an Editor's Choice award for "Best HPC Collaboration between Government and Industry."

In addition, we are working with the three NNSA laboratories (Livermore, Los Alamos, and Sandia) and with two other SC laboratories (Argonne and Lawrence Berkeley) on the Exascale Computing Project (ECP). Launched by DOE in FY 2017, the ECP is focused on accelerating the delivery of a capable exascale computing ecosystem.[1] China plans to have its first exascale

[1] In this context, "capable" addresses the need for systems that can deliver high-fidelity solutions in less time and address problems of greater complexity than today's supercomputers, while operating reliably in a power envelope of 20 to 30 megawatts and supporting a broad spectrum of applications and workloads. "Exascale" refers to computing systems at least fifty times as powerful as those in operation today. A "computing ecosystem" includes system software, hardware technologies and architectures, and the scientific applications that will run on advanced systems, as well as development of the workforce needed to operate and exploit these resources.

system in operation by 2020. The ECP is integrating the strengths of the six participating laboratories to ensure that researchers in the United States will have access not only to physical computing systems with the requisite power, but also to the tools that they will need to deliver breakthrough modeling and simulation solutions that address the most critical challenges in scientific discovery, energy assurance, economic competitiveness, and national security. The benefits of the ECP will extend beyond DOE to other federal agencies and to U.S. industry.

GOVERNANCE OF THE NATIONAL LABORATORIES

With the exception of the National Energy Technology Laboratory, the DOE national laboratories are owned by the U.S. government and managed and operated by contractors. This government-owned/contractor-operated (GOCO) approach has been in existence since the Manhattan Project, when it provided the flexibility needed to accomplish the development of the first nuclear weapons. It was formally adopted for the national laboratories in the Atomic Energy Act of 1946, under which Congress authorized "contracts for the operation of Government-owned plants so as to gain the full advantage of the skill and experience of American industry."

These management and operation (M&O) contracts remain the key instrument for implementing the GOCO model. The relationship between DOE and its contractors is ideally a partnership, in which DOE establishes objectives for the laboratories' R&D programs, based on its mission needs, and exercises the controls necessary to assure security, safety, and the prudent use of public funds, while allowing contractors selected for their technical ability and managerial expertise to determine how to carry out day-to-day operations. Simply stated, DOE decides ***what*** is to be done, and the M&O contractors decide ***how*** it is to be done.

Over time, however, the M&O contracting environment has increasingly become one in which contractors are subjected to increasing oversight, duplicative and burdensome regulations, and greater liability, while having less authority and autonomy. Dozens of past investigations, studies, and reviews of DOE and the national laboratories have focused on the need to return to the intent of the original GOCO model as stated in a clause found in some early M&O contracts: that "this agreement shall be carried on in a spirit of partnership and friendly cooperation with a maximum of effort and common sense in achieving their common objectives."

For example, in October 2015 the Commission to Review the Effectiveness of the National Energy Laboratories (CRENEL) made 36 recommendations designed "to ensure that the laboratories are able to operate as efficiently and effectively as possible so that the Nation realizes the maximum benefit from this national asset in the years ahead."[2] Many of these recommendations focused on restoring the partnership between DOE and its laboratories to establish and maintain a culture of trust and accountability.

REALIZING THE POTENTIAL OF THE NATIONAL LABORATORIES

I am happy to report that DOE is working to drive fundamental change in its management of the national laboratories, concentrating in four areas:

- partnering with leadership to leverage the laboratories' capabilities to address national priorities;

[2] *Securing America's Future: Realizing the Potential of the Department of Energy's National Laboratories—Final Report, of the Commission to Review the Effectiveness of the National Energy Laboratories,* Vol. 1: Executive Report, October 28, 2015.

- reforming DOE governance of national laboratories to recapture the M&O contract model;
- implementing regulatory and policy reforms to alleviate unnecessary burdens placed on the laboratories; and
- closely coupling the work of the national laboratories with the private sector to support technology innovation that advances U.S. global competitiveness and leadership.

Focus on National Priorities

The national laboratories represent a remarkable asset for the nation. Over the past 75 years, they have consistently provided the science and technology needed to address compelling national problems, and they offer an extraordinary set of resources for sustaining and advancing the national, economic, and energy security of the United States in the 21st century.

DOE has adopted a laboratory strategic planning process, modeled on processes developed by SC, that is improving the strategic alignment of the national laboratories and enabling them to work more effectively, both collectively and individually, to meet DOE mission needs and address national priorities. DOE and the laboratories are using this process to produce plans for accomplishing the Department's missions and conducting world-class R&D.[3]

[3] For details, see "DOE Laboratory Strategic Planning," p. 83 in *Annual Report on the State of the DOE National Laboratories,* U.S. Department of Energy, Washington, D.C., January 2017.

Improved Governance of Laboratories

DOE and its contractors are working to streamline and simplify contract mechanisms to improve partnership, reduce transactional oversight, and deliver more R&D for the federal dollars invested at the national laboratories, while ensuring that contractors are held accountable. Contract reform efforts are paying off in better understanding of performance expectations and requirements, reductions in transactional approvals, and better tailoring of oversight and control to potential risks.

I want to highlight the laboratory appraisal process developed by SC, which has been in place for a decade. This process initially established a common structure and scoring system across the ten SC national laboratories. It has now been implemented for all 16 GOCO laboratories. It emphasizes the importance of delivering the science and technology necessary to meet DOE's mission needs; operating the laboratories in a safe, secure, responsible and cost-effective way; and recognizing the leadership, stewardship, and value-added provided by the M&O contractors. Every year, laboratory staff work with DOE to develop a Performance Evaluation and Measurement Plan (PEMP) that establishes the foundation for an annual evaluation of the contractor's scientific, technological, managerial, and operational performance. The final product is an annual "report card" for each laboratory that is posted on the DOE website. DOE uses the results of the process to determine the performance fee that is paid to the M&O contractor. At some laboratories, strong performance can result in an extension of the contract. Performance evaluations also provide DOE with input to its decisions on whether to extend or compete M&O contracts when they expire.

Our experience at ORNL has been that this process has delivered on its goals of improving transparency, raising the level of involvement of DOE leadership, increasing consistency in the way the laboratories are evaluated, and incentivizing contractor performance. The process provides a way of holding the contractor accountable for results, and it helps to build trust by establishing a clear understanding of what is expected.

More recently, the increasing use of contractor assurance systems has allowed contractors to more effectively manage processes, resources, and outcomes. These systems support DOE in determining the necessary level of oversight for activities at the national laboratories. For example, ORNL recently became the first national laboratory to implement a Fast Track CRADA Program. This program will streamline the execution of cooperative R&D agreements (CRADAs), which are a key mechanism for technology transfer, by exploiting ORNL's robust contractor assurance processes to simplify the involvement of DOE's ORNL Site Office. The flexibility provided by the GOCO model and the "spirit of partnership and friendly cooperation" that is a vital element of our relationship with DOE's ORNL Site Office were key factors in our ability to implement this new tool for accelerating the transition of DOE-sponsored innovations to beneficial use.

Regulatory and Policy Reform

In accordance with the policy outlined in Executive Order 13777, "Enforcing the Regulatory Reform Agenda," DOE is placing a high priority on reducing regulatory burdens that impede competitiveness and innovation. The Department's Regulatory Reform Task Force identified

DOE's "inward-facing regulations" on national laboratory operations as an area presenting substantial opportunities for beneficial and cost-saving improvements.

The task force also sought input from outside entities, and the NLDC responded with a set of proposals for improving the management and operations of the national laboratory complex. DOE embraced a number of these proposals and established cross-functional teams from across the Department and the national laboratories to evaluate, enhance, and implement the improvements.

Good progress is being made. One of these teams is working on improving the M&O contract mechanism, with an eye to strengthening partnerships and reducing transactional oversight. Another is taking action to revise the DOE rule governing nuclear safety management (10 CFR 830) to address recognized issues that have resulted in substantial unnecessary costs associated with the operation of nuclear facilities. A team evaluating human resources functions looked at some 25 required reports and determined that 55 percent of them could be eliminated or revised to incorporate efficiencies. Another 25 percent of required reports are expected to be eliminated by the heads of contracting authorities. Other efforts are moving forward.

This process has fostered a collaborative environment in which DOE and national laboratory staff are working toward shared goals and outcomes, with a view to freeing up human capital to focus on mission. In November, the NLDC submitted a second set of proposals to DOE for consideration. I am confident that continuing efforts along these lines will result in additional savings and extend the value of the dollars invested in the national laboratories.

In terms of policy reform, Secretary Perry recently announced a realignment of DOE's organizational structure "to advance its policy goals consistent with its statutory requirements." At ORNL, we look forward to working with our sponsors across the Department to deliver the science and technology that they need to execute their statutory missions.

Collaborating with Industry

DOE is taking steps to ensure that scientific and technical advances can move beyond the national laboratories to increase the economic impact of the intellectual property developed as a result of federally funded R&D. The laboratories are being encouraged to work with the private sector to find and implement new approaches for translating early-stage innovations to viable market options. These efforts leverage traditional funding streams and programs focused on early-stage research with private-sector and foundation support and market knowledge that provide a pathway to create new businesses, product lines, and jobs. DOE's Office of Technology Transitions provides valuable coordination.

In 2011, DOE and the national laboratories worked together to develop the Agreements for Commercializing Technology (ACT) mechanism to provide potential industry partners with an alternative to CRADAs and the traditional Strategic Partnership Projects (SPP, formerly Work for Others) agreements. Following a successful pilot program, Secretary Perry has made the ACT mechanism available at all of the national laboratories. CRADAs and SPP agreements are between the national laboratory and a third-party company, and they must be approved by DOE. Although both have been successfully used to transfer technology to industry, they have often

been criticized as being too complicated and taking too long to implement. They also require industry partners to assume all risk and to make advance payments before work can begin.

ACT agreements are contracts between the M&O contractor and a third-party company. Among their key characteristics are the following:

- They provide a more flexible framework for negotiation of intellectual property rights, as well as a streamlined approval process.
- They allow M&O contractors to negotiate terms that are better aligned with industry practice, attracting more private investment, and to assume contractual and financial risk.
- They provide a way for national laboratories to participate in groups formed to address complex technological challenges that are of mutual interest.

Secretary Perry has also authorized a pilot program that will expand the use of ACT to allow organizations to partner with the national laboratories on federally funded projects. We look forward to the opportunities that will arise through this new program.

Another innovative approach to accelerating the development of early-stage technologies is the Lab-Embedded Entrepreneurship Programs sponsored by EERE: Cyclotron Road at Lawrence Berkeley, Chain Reaction Innovations at Argonne, and Innovation Crossroads at ORNL. Our Innovation Crossroads program matches aspiring entrepreneurs in energy and advanced manufacturing with experts, mentors, and networks in technology-related fields who can assist these early-career innovators in taking their ideas from R&D to the marketplace. Last year, we welcomed our first cohort of innovators. They are working on a novel approach to growing high-

quality carbon nanotubes from carbon dioxide, an active energy storage system that manages different sources of thermal energy to inexpensively store electricity, and an advanced nuclear reactor that offers high efficiency, low cost, and enhanced safety.

Innovation Crossroads participants are paired with students from the Bredesen Center for Interdisciplinary Research and Graduate Education, who provide assistance with market research and customer discovery. The Bredesen Center was created as a partnership of ORNL and the University of Tennessee in 2012. It offers doctoral degrees in energy science and engineering and in data science and engineering, and it enables students not only to conduct multidisciplinary research at ORNL but also to cultivate skills in science and technology policy, entrepreneurship, and outreach. We have extended the Bredesen Center model to more than 25 additional universities across the nation.[4] These activities help to build a robust pipeline of talent in fields of vital importance to DOE and the nation. Many of these students go on to work in industry, and several have launched companies of their own.

[4] Universities offering doctoral research programs through ORNL's Graduate Opportunities (GO!) Program: Boston University, the Colorado School of Mines, Duke University, Florida State University, Georgia Institute of Technology, Michigan State University, Michigan Technological University, North Carolina State University, Ohio State University, Oregon State University, Purdue University, Rensselaer Polytechnic Institute, Rice University, Texas A&M University, the University of California–Davis, the University of Florida, the University of Illinois at Urbana-Champaign, the University of Missouri, the University of Nebraska–Lincoln, the University of Virginia, the University of Wisconsin–Madison, the University of Nevada–Las Vegas, Virginia Polytechnic Institute and State University, Washington State University and six Tennessee universities: Middle Tennessee State University, Tennessee Technological University, the University of Memphis, the University of Tennessee–Chattanooga, the University of Tennessee–Knoxville, Vanderbilt University,

CLOSING REMARKS

Our nation is facing a formidable set of challenges: ensuring our national security in a changing world; increasing the availability of clean, reliable, and affordable energy while protecting the environment; improving human health; and enhancing U.S. competitiveness in the global economy by fostering scientific leadership and encouraging innovation. The DOE national laboratories are uniquely equipped and positioned to make substantial contributions to overcoming these challenges.

DOE is taking action to make the national laboratories more efficient and effective, which will enable these institutions to focus their distinctive capabilities on delivering the advances in science and technology that are vital to ensuring our energy security, national security, and global competitiveness. The M&O contractor community is committed to working with DOE to build the culture of trust and accountability that will ensure the greatest possible return on the nation's investment in the DOE national laboratories.

Thank you again for the opportunity to testify. I welcome your questions on this important topic.