Interim Report of the Commission to Review the Effectiveness of the National Energy Laboratories

Jared L. Cohon, co-chair

TJ Glauthier, co-chair

Norman R. Augustine

Wanda M. Austin

Charles Elachi

Paul A. Fleury

Susan J. Hockfield

Richard A. Meserve

Cherry A. Murray

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Executive Summary

The Commission to Review the Effectiveness of the National Energy Laboratories was charged by Congress in January 2014 to evaluate the mission, capabilities, size, performance, governance, and agency oversight of the 17 Department of Energy (DOE) laboratories. Given the incredibly broad scope and aggressive timeline (the original deadline was February 2015), the Secretary of Energy and Congress agreed to split the task into two phases. This interim report contains the preliminary observations and recommendations gleaned from Phase 1 of the study, which consisted of a literature review; visits to five of the National Laboratories; semi-structured interviews with staff from across the National Laboratories, DOE, other Federal agencies, companies, other non-governmental organizations, and additional interested parties; and presentations at monthly public Commission meetings.

The Commission notes that the purpose of the National Laboratories is to provide critical capabilities and facilities in service of DOE's mission and the needs of the broader national and international science and technology (S&T) community, including other Federal agencies, academia, and private industry. The National Laboratories are successfully fulfilling that mission today. While the Commission believes significant improvements can be made to many aspects of DOE management and governance of the laboratories, those issues do not detract from the National Laboratories' remarkable contributions to the American public. In Phase 2 the Commission will focus on ways to make the process of carrying out their missions more efficient and effective.

The sections below highlight the major observations that the Commission has made during its Phase 1 work, which should be viewed as preliminary.

Purpose and Importance of the National Laboratories

The National Laboratories are intended to provide critical capabilities and facilities in service of DOE's missions and the needs of the broader national and international S&T communities. The National Laboratories do this both as individual centers of excellence and as a network of laboratories around the country that often work in concert.

All of the National Laboratories, save one, are run by non-governmental organizations as Federally Funded Research and Development Centers (FFRDCs). This relationship allows expert organizations to manage the laboratories and to be accountable for laboratory performance under the overall direction of DOE. When the FFRDC model functions properly, it provides significant technical and management benefits to both the

DOE and the laboratories. The approach, as originally developed, is designed to enable the National Laboratories to retain an exceptionally skilled workforce, be agile in shifting resources to new areas as needs change over time, and utilize the best management practices from the contractor organizations.

Major Recurrent Themes from Past Reports (and the lack of meaningful change)

There have been an abundance of reports over the past 40 years detailing shortcomings in the relationship between the DOE and its laboratories. The reports provide a strikingly consistent pattern of criticism and similar set of recommendations for improvement. Yet, for the most part, these recommendations have not been implemented effectively, as demonstrated by the fact that the same problems continue to be cited in report after report.

Many of the problems cited in earlier reports stem from a “broken trust” in the relationship between DOE and the National Laboratories. This shows up as an excessive level of transactional oversight and control by DOE over the activities of the laboratories, in conflict with the ideal relationship that is envisioned in the FFRDC model. The situation stems from what appears to be a high level of risk aversion exacerbated by disparate attitudes on risk management at DOE headquarters and the field/site offices.

The Commission is working to identify root causes that have prevented significant improvements in these areas over the years. Importantly, the Commission notes the absence of a standing body or internal DOE mechanism to advocate for implementation of recommended changes, perform systematic assessments, and evaluate progress over time. The Commission will explore options for addressing the implementation gap in Phase 2 as well.

Performance in Support of DOE

Based on its preliminary observations, the Commission believes that the National Laboratories’ research programs and capabilities are well-aligned with DOE’s missions and strategic priorities. There are robust processes in some program offices to provide strategic oversight, evaluation and direction to the laboratories. However, those processes are not consistently utilized throughout the Department. The most effective processes are those in the Office of Science, which occur regularly and include experts from other laboratories, universities and the private sector. These are used both for annual review of each of the laboratories, and for in-depth reviews of key program areas across the enterprise.

The Commission strongly believes that strategic planning for both the Department and the laboratories is best accomplished jointly, with DOE and its laboratories working together. The level of laboratory involvement in DOE strategic planning varies by office. Secretary Moniz and his management team are making great improvements by involving laboratory directors and their staff in the Department's own strategic planning process. It is important to institutionalize this so that future Secretaries will continue this practice.

The Commission recommends, as a preliminary measure, that all DOE program offices adopt, to the extent possible, the procedures and processes that DOE's Office of Science has in place for guiding and assessing the quality and alignment of the 10 laboratories under its stewardship.

There is some level of duplication among the laboratories in both user facilities and R&D programs, most of which is intentional, managed, and beneficial to the nation. For example, the Commission is aware of examples in which duplication and competition among the weapons laboratories of NNSA have resulted in significant reductions in cost and schedule and, in some cases, reductions in size and weight of the weapons.

At early stages of new research, it is appropriate to encourage multiple researchers to carry out small-scale projects and explore many different potential avenues. In mature program areas, the Department has processes to provide strategic oversight and guidance, as noted above. However, in the intermediate stages, DOE often waits too long to provide strategic guidance to the laboratories. As a result, there is some period of time during which the labs are competing with one another to lay claim to new research areas.

Engagement with and Support to the Broader S&T Community

The laboratories are national assets, performing important work that goes beyond DOE's own programs and supports other Federal agencies, other public institutions, universities, and the private sector. The laboratories provide unique capabilities in terms of expert personnel capable of providing both large-scale, long-term support and meeting rapid response needs. They also build and operate state-of-the-art research facilities that are used extensively by the broader science and technology community in support of many diverse public and private needs.

The Commission has observed that DOE has policies in place to ensure that work supporting other agencies meets necessary criteria and, in appropriate areas, aligns with the Department's missions. The Commission will be examining in more detail the processes and practices to meet those policies, at both DOE and the National Laboratories.

On the whole, other Federal agency customers are very satisfied with the quality and value of the work performed by the laboratories. However, many feel laboratory costs are high relative to other institutions, and they are less satisfied with their interactions with DOE headquarters. Just as there is a lack of strategic planning across the entire National Laboratory complex, so too is there a lack of strategic planning involving other Federal agencies with respect to S&T requirements for the DOE laboratories. In this regard, the Mission Executive Council, consisting of the DOE, Department of Defense, Department of Homeland Security, and the Intelligence Community, is not as effective a coordination resource as it was intended to be.

DOE should establish techniques to make the Work for Others (WFO) process more efficient, such as institutionalizing ongoing efforts to streamline the contracting process through more consistent use of umbrella agreements and oversight mechanisms dedicated to shortening the timeline of the approval process; encouraging greater use of personnel exchanges and "customer relationship managers"; creating a central point of contact in DOE headquarters to field questions from WFO customers about where specific capabilities lie within the laboratory complex; and supporting efforts to strengthen the Mission Executive Council.

While the Congressional charge specifically targeted laboratory work supporting other agencies, the Commission felt it was important to also highlight the laboratory user facilities, collaborations with academia, and industry partnerships and technology transfer, which have a broad impact on the national S&T community. The Commission is still in the preliminary stages of data collection and analysis for these topics. Both academia and the National Laboratories benefit from collaborations that occur through individual research partnerships and multi-institution funding constructs, such as the Energy Frontier Research Centers and the Energy Innovation Hubs. The Commission intends to examine these programs more fully, as the results have been mixed.

The user facilities at the National Laboratories are a unique and enormously valuable resource to researchers at other Federal agencies and to academic institutions and the private sector here and abroad. All of the user facilities run competitive, peer-reviewed processes to allocate time among potential researchers and many are over-subscribed. The Commission will continue to review the processes by which DOE conducts long term planning and oversight of the user facilities across the program offices.

Technology transfer and partnering with industry are an important part of the overall mission of the National Laboratories. There are hundreds of CRADAs and other forms of collaboration with the private sector throughout the complex. However, the support for technology transfer is inconsistent across the laboratories and across the DOE program offices. In Phase 2 of its effort, the Commission will examine the barriers to effective and efficient collaboration of the laboratories with industry to ensure that the impact of the National Laboratories on the U.S. economy is all it can be.

Laboratory Directed Research and Development (LDRD)

LDRD has a long history of support and accomplishments, dating back to 1954 when it was first authorized by the Congress. LDRD is the sole source of discretionary research funding under the control of the laboratory director for the National Laboratories. LDRD is an important recruitment and retention tool for all the National Laboratories, but is especially critical at the NNSA laboratories, which must attract new staff into post-doctoral positions before being able to give them visibility into the broader, often classified, work done by those laboratories.

In the life cycle of new research topics, LDRD is a crucial resource in supporting cutting edge exploratory research prior to the time that a research program is identified and developed by DOE. It is worthwhile and appropriate for multiple LDRD projects at various laboratories to be funded in the same topic area as a means of exploring different paths toward an ultimate program in the field. These small, early stage projects provide valuable insights for the DOE program planning process. Based on preliminary observations, it appears that many of today's major programs at the laboratories have stemmed from LDRD projects.

There are formal requirements for LDRD projects to be selected competitively and to ensure they are innovative, new areas of research that are not already covered by existing programs. However, the Commission believes that the statutory requirement that every LDRD project be individually reviewed by DOE—which totaled 1,662 projects in fiscal year 2014—may be excessively costly and burdensome to both Departmental and laboratory staff. The Commission intends to review whether approaches such as periodic audits or a sampling of each year's project pool may be sufficient for compliance and a more efficient alternative to current oversight.

Appropriate Size of National Laboratories to Meet National Needs

The question of whether the DOE laboratory complex is appropriately sized is difficult to answer. Important, related questions are whether the proper proportion of DOE funding is sent to the laboratories relative to academia and industry and whether the laboratory complex is operating as efficiently and effectively as possible, both of which will be explored further in Phase 2.

The Federal funding of DOE's annual R&D budget has been relatively constant over the past 40 years. The Department's share of Federal R&D spending has remained at less than 9% for the past 20 years, falling from a high of 18% in the 1970s and 1980s. These levels are appropriate given the pressures on national R&D budgets and the importance of the missions of DOE and the National Laboratories.

The appropriate size of each individual laboratory is determined by DOE through a strategic review of duplication, alignment, and quality of R&D. There may be opportunities for streamlining of staff and cost savings in the DOE headquarters and field/site offices through changes to the current transactional oversight roles used to ensure proper laboratory management.

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The Commission wishes to acknowledge that the current Secretary of Energy and his management team have been working actively to improve management practices and to resolve many of the problems that have been cited by this and earlier reports. One of the most noteworthy is the changed relationship between DOE and the laboratories, to one of greater openness and partnership, with the laboratories serving as “trusted advisors” in the spirit of the FFRDC model. The Commission supports those efforts and will explore recommendations to continue and extend that work, and importantly, to institutionalize such changes so that they will be maintained in subsequent Administrations.

In summation, the Commission has concluded that the 17 laboratories continue to provide value to DOE and the Nation, whether through addressing DOE mission needs, stewardship of scientific user facilities, work for other Federal agencies, or collaborations with private industry. The Commission also notes that recommendations concerning the laboratory complex must account for diversity of size, practices, and mission scope of the laboratories and DOE program offices. Finally, the Commission recognizes that the partnership between DOE and its National Laboratories is vitally important for the Nation’s national security and competitiveness, as well as for the advancement of basic science.

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1. Introduction

A. Congressional Charge

Section 319 of the Consolidated Appropriations Act, 2014 (Public Law No. 113-76) directed the Secretary of Energy to establish the Commission to Review the Effectiveness of the National Energy Laboratories. The Commission is charged with reviewing the 17 Department of Energy (DOE) National Laboratories.[1] It was established in May 2014 and held its first meeting in July 2014. See Appendix A for the names and biographies of the Commissioners. According to the statutory language:

> (2) The Commission shall address whether the Department of Energy's national laboratories—
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> (A) are properly aligned with the Department's strategic priorities;
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> (B) have clear, well understood, and properly balanced missions that are not unnecessarily redundant and duplicative;
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> (C) have unique capabilities that have sufficiently evolved to meet current and future energy and national security challenges;
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> (D) are appropriately sized to meet the Department's energy and national security missions; and
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> (E) are appropriately supporting other Federal agencies and the extent to which it benefits DOE missions.
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> (3) The Commission shall also determine whether there are opportunities to more effectively and efficiently use the capabilities of the national laboratories, including consolidation and realignment, reducing overhead costs, reevaluating governance models using industrial and academic bench marks for comparison, and assessing the impact of DOE's oversight and management approach. In its evaluation, the Commission should also consider the cost and effectiveness of using other research, development, and technology centers and universities as an alternative to meeting DOE's energy and national security goals.
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> (4) The Commission shall analyze the effectiveness of the use of laboratory directed research and development (LDRD) to meet the

[1] The 17 laboratories are Ames National Laboratory, Argonne National Laboratory, Brookhaven National Laboratory, Fermi National Accelerator Laboratory, Idaho National Laboratory, Lawrence Berkeley National Laboratory, Lawrence Livermore National Laboratory, Los Alamos National Laboratory, National Energy Technology Laboratory, National Renewable Energy Laboratory, Oak Ridge National Laboratory, Pacific Northwest National Laboratory, Princeton Plasma Physics Laboratory, Sandia National Laboratories, Savannah River National Laboratory, SLAC National Accelerator Laboratory, and Thomas Jefferson National Accelerator Facility.

> Department of Energy's science, energy, and national security goals. The Commission shall further evaluate the effectiveness of the Department's oversight approach to ensure LDRD-funded projects are compliant with statutory requirements and congressional direction, including requirements that LDRD projects be distinct from projects directly funded by appropriations and that LDRD projects derived from the Department's national security programs support the national security mission of the Department of Energy. Finally, the Commission shall quantify the extent to which LDRD funding supports recruiting and retention of qualified staff. (Consolidated Appropriations Act, 2014, Public Law No. 113-76, 128 Stat. 179 [2014]).

Appendix B provides the complete text of Section 319. Due to the scope of the Commission's task and the aggressive timeline, Secretary of Energy Ernest Moniz and Senator Feinstein, Chair of the Senate Energy and Water Appropriations Subcommittee, agreed to separate the Commission's charge into two phases. (See Appendix C for a letter about their agreement.) The agreement called for Phase 1 to focus on the mission and strategic planning of the laboratories, and Phase 2 to target the operation and oversight of the laboratory complex. LDRD as it relates to the issues outlined above is to be considered in both phases of the Commission's task. This interim report provides the outcome of Phase 1.

B. Approach

The findings and observations in this interim report are based on a literature review; visits to five of the National Laboratories; semi-structured interviews with staff from across the National Laboratories, DOE, other Federal agencies, companies, other non-governmental organizations, and additional interested parties; and presentations at monthly public Commission meetings.

The Commission's research team reviewed reports from the National Research Council (NRC), Congressional Research Service (CRS), Government Accountability Office (GAO), and DOE Office of the Inspector General (OIG), as well as past commissions; strategic plans, orders, directives and other official DOE and National Laboratory documents such as LDRD reports and user facility publications; and relevant legislation and regulations. The Commission also considered recently completed and ongoing studies.[2] The literature review put the subject in historical context and provided

[2] Congressional Advisory Panel on the Governance of the Nuclear Security Enterprise, National Research Council (NRC) Assessment of the Governance Structure of the NNSA National Security Laboratories, NRC Peer Review and Design Competition Related to Nuclear Weapons, and Secretary of Energy Advisory Board (SEAB) National Laboratory Task Force. It should be noted all of these studies share have some members in common with this commission.

information relevant to the Commission's charge, including stewardship, alignment, duplication, and core capabilities of the National Laboratories.

During Phase 1, the Commission visited 5 of the 17 National Laboratories: Lawrence Livermore National Laboratory, a National Nuclear Security Administration (NNSA) laboratory; Fermi National Accelerator Laboratory, an Office of Science single-program laboratory; Lawrence Berkeley National Laboratory and Argonne National Laboratory, Office of Science multi-program laboratories; and the National Renewable Energy Laboratory (NREL), the Office of Energy Efficiency and Renewable Energy laboratory. Although information from these visits showcase part of the laboratory complex's diversity, findings and observations from these first laboratory visits should be considered preliminary until the Commission completes Phase 2 of its task, during which the Commission plans to visit the 12 remaining laboratories. See Appendix D for descriptions of the 17 laboratories.

Laboratory visits consisted of brief tours of the facilities that highlighted a few select facilities and research programs; meetings with top laboratory officials to discuss the questions presented by Congress; meetings with the site/field office to provide a better sense of its role and the relationship between the laboratories and DOE; and lunch with early-career scientists and engineers to understand the different cultures at each laboratory.

The Commission's research team conducted semi-structured interviews with over 160 individuals from across the National Laboratories, DOE, other Federal agencies, and other interested organizations. Interviewees discussed historical context, stewardship, alignment, quality, size, duplication, core capabilities, LDRD, Work for Others (WFO), and related topics. Appendix E provides a list of the organizations represented in the interviewees.

Throughout the study, the Commission invited DOE and National Laboratory officials and subject-matter experts to public meetings to present their insights on various topics and perspectives related to the charge. The Commission has heard from industry and university partners, National Laboratory directors, the scientific community, congressional staff, other Federal agencies, management and operations contractors, and other stakeholders.

C. Scope of Report

Through the course of its investigation, the Commission has found the topics of Phase 1 and 2 to be complex and inextricably interconnected. In addition, and as noted previously, the Commission has visited less than a third of the laboratories prior to the Phase 1 report deadline. For these reasons, the observations and recommendations in this report should be viewed as preliminary. While the Commission feels confident in the validity of its preliminary observations and recommendations, there is the possibility they could be modified later, once the full study is completed. After visiting the totality of the laboratory complex and completing its analysis of all Phase 1 and 2 topics, the Commission will make its final recommendations. Given the urgency and interest in the study from Congress and the Administration, the Commission felt it was important to provide a sense of its observations and recommendations, albeit preliminary.

D. Organization of Interim Report

Because of the inherent interdependence of the topics raised by Congress and the intricacy of the National Laboratory complex itself, the Commission found it difficult to address each of the topics one at a time. Instead, Chapter 2 of the report discusses the purpose of the National Laboratories in the context of supporting the DOE and the Nation, whereas the remainder of the report assesses the success of the laboratories in performing these functions. Specifically, the report is organized as follows:

- Chapter 2 sheds light on the importance of the National Laboratories in terms of DOE missions and goals and the National Laboratories' purpose. This chapter also provides background on the relationship between DOE and its National Laboratories.
- Chapter 3 characterizes recurring themes from past reports on the National Laboratories and provides observations about impediments to implementing reiterated recommendations.
- Chapter 4 details the performance of the National Laboratories with regard to support of DOE.
- Chapter 5 discusses the performance of the National Laboratories with regard to engagement and support of the broader science and technology (S&T) community, including other Federal agencies.
- Chapter 6 provides information related to LDRD.
- Chapter 7 explores the question of the appropriate size of the National Laboratory complex.
- Chapter 8 summarizes the preliminary observations of Phase 1.
- Supporting documentation: A series of appendixes to the report provide Commissioner biographies, congressional charge, descriptions of the laboratories, list of organizations represented in interviews, recommendations

from past reports, list of user facilities, supplementary LDRD information, and other supporting materials.[3]

[3] Additional supporting documentation, including Commission meeting minutes, can be found on the Commission's website at http://energy.gov/labcommission/commission-review-effectiveness-national-energy-laboratories.

2. Purpose and Importance of the National Laboratories

Broadly stated, the purpose of the DOE National Laboratories is to enable the DOE to meet its mission by performing research and development (R&D), sustaining core capabilities important to national interests, supporting user facilities, and engaging and supporting the broader science and technology (S&T) community.[4] This chapter briefly introduces the current DOE National Laboratory complex, describes the mission and strategic goals of the DOE, explores the stated purpose of the National Laboratories, and discusses the ideal relationship between the DOE and National Laboratories. Subsequent chapters will detail the Commission's findings as it assesses the performance of the DOE and National Laboratories. These topics together highlight the importance of the laboratories not only to DOE, but to the Nation as a whole.

A. DOE Laboratory Complex

Figure 1 shows the locations across the country of the 17 laboratories in DOE's laboratory complex. When categorized by their research focus and DOE stewarding office, there are 10 science laboratories stewarded by the DOE Office of Science (SC), 3 national security laboratories overseen by the National Nuclear Security Administration (NNSA), and 4 laboratories stewarded by the applicable DOE program office, (one each by the Office of Energy Efficiency and Renewable Energy [EERE], the Office of Environmental Management [EM], the Office of Fossil Energy [FE], and the Office of Nuclear Energy [NE]). Table 1 provides information on each laboratory, including the managing contractor, the DOE stewarding office, and fiscal year (FY) 2014 cost and size data.

Sixteen of the 17 laboratories are Federally Funded Research and Development Centers (FFRDCs), managed through a management and operating (M&O) contract.[5] M&O contractors for the National Laboratories include individual universities, university consortia, nonprofit corporations, industrial firms, and partnerships involving the aforementioned types of organizations. The National Energy Technology Laboratory (NETL) is the sole government-owned, government-operated (GOGO) laboratory.[6]

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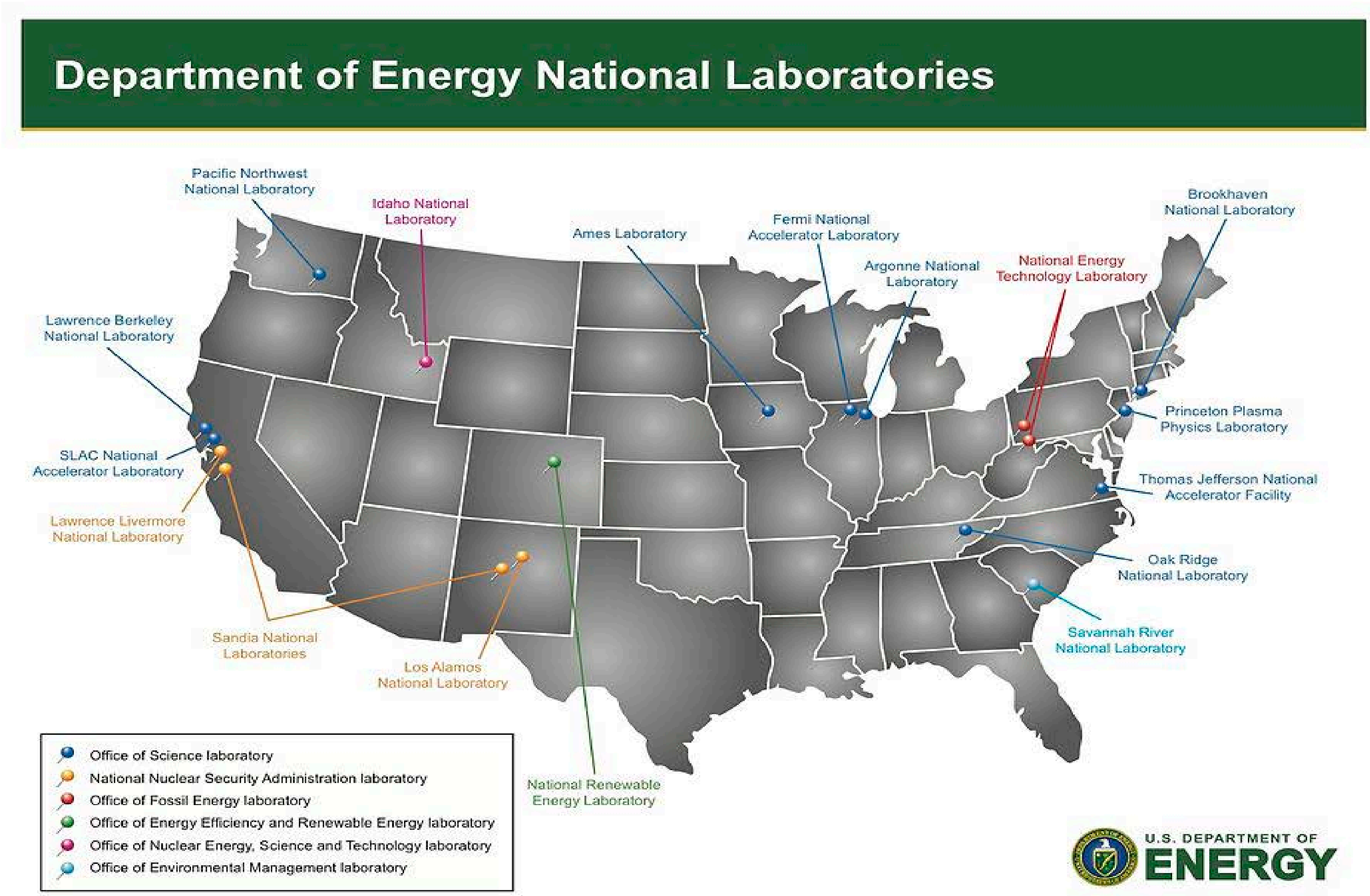
4 Department of Energy (DOE), *Strategic Plan 2014-2016* (Washington, DC: DOE, 2014).

5 The Atomic Energy Act of 1946 (P.L. 79-585) formalized the M&O contract and established the Atomic Energy Commission, a precursor to the DOE.

6 The Commission will visit NETL in Phase 2 and will discuss the benefits of the GOGO model in the final report.



Source: Map provided by DOE.

Figure 1. Locations of the DOE National Laboratories

Table 1. Characteristics of Department of Energy National Laboratories

Laboratory	Managing Contractor	Stewarding Office	Budget from DOE (FY 2014)*	Total Operating Cost (FY 2014)†	Size (FTE)‡	Year Est.
Ames National Laboratory	Iowa State University	SC	$33 M	$36 M	310	1947
Argonne National Laboratory	UChicago Argonne, LLC	SC	$560 M	$810 M**	3,500	1946
Brookhaven National Laboratory	Brookhaven Science Associates, LLC	SC	$500 M	$630 M**	2,900	1947
Fermi National Accelerator Laboratory	Fermi Research Alliance, LLC	SC	$420 M	$420 M	1,700	1967
Idaho National Laboratory	Battelle Energy Alliance, LLC	NE	$1.1 B	$1.3 B††	4,100	1949
Lawrence Berkeley National Laboratory	University of California	SC	$570 M	$770 M	3,400	1931
Lawrence Livermore National Laboratory	Lawrence Livermore National Security, LLC	NNSA	$1.1 B	$1.5 B**	5,800	1952
Los Alamos National Laboratory	Los Alamos National Security, LLC	NNSA	$1.9 B	$2.1 B	10,200	1943
National Energy Technology Laboratory	N/A	FE	$730 M	$840 M	1,500	1910
National Renewable Energy Laboratory	Alliance for Sustainable Energy, LLC	EERE	$270 M	$400 M	2500***	1977
Oak Ridge National Laboratory	UT-Battelle, LLC	SC	$1.1 B	$1.4 B	4,600	1943
Pacific Northwest National Laboratory	Battelle Memorial Institute	SC	$570 M	$850 M	4,300	1965
Princeton Plasma Physics Laboratory	Princeton University	SC	$80 M	$81 M	430	1951
Sandia National Laboratories	Sandia Corporation	NNSA	$1.7 B	$2.5 B††	9,500	1949
Savannah River National Laboratory	Savannah River Nuclear Solutions, LLC	EM	$16 M	$250 M‡‡	830	1951
SLAC National Accelerator Laboratory	Stanford University	SC	$400 M	$350 M**	1,600	1962
Thomas Jefferson National Accelerator Facility	Jefferson Science Associates, LLC	SC	$160 M	$170 M	730	1984

* Budget figures are approximate and are from DOE FY 2015 Budget Justification; total operating cost differs from these values as the laboratories receive funds from external sources through partnerships and work for other agencies.

† Operating cost figures for the SC laboratories are from the Office of Science FY 2014 Ten-Year Laboratory Plan. Other figures are either from laboratory visits or from laboratory websites.

‡ FTE means full-time equivalent employees and does not include other contractors. Size figures are approximate and are from laboratory websites, except for SC laboratories, which are from the Office of Science FY 2014 Ten-Year Laboratory Plan.

** Figures are from FY 2013.

†† Figures are from FY 2012.

‡‡ Figures are from FY 2010.

*** This number includes temporary employees (87 FTEs) and contractors (797 FTEs) as of September 2014.

B. DOE's Mission and Strategic Goals

DOE (and its precursor agencies) is a conglomerate that includes responsibility for energy, science, nuclear weapons, and environmental cleanup.[7] Over time its strategic priorities have shifted in response to specific needs but the three goals outlined in DOE's 2014–2018 Strategic Plan—science and energy, nuclear security, and management and performance—are consistent with these historic mission areas.[8]

In many cases, the mission of the Department and the corresponding roles of the National Laboratories serve the Nation more broadly than one might expect if one thinks DOE's only purpose is "energy." Of course, advancing the state of energy technology is critically important to the Department's core mission. But the Department is also the primary Federal funding agency for physical science research and large-scale scientific tools.[9] In addition, DOE is responsible for the U.S. nuclear stockpile and the environmental cleanup required as a consequence of nuclear manufacturing and storage. This aspect of DOE's mission has far reaching implications for national security and environmental science, among other issues.

DOE is unique among Federal agencies in how it funds research. Rather than focusing on proposals driven by a single principal investigator, the Department funds both large-scale multidisciplinary research and large expensive facilities that universities and industry are unable or unwilling to invest in. These facilities are highly pertinent to advancement of science in areas beyond DOE's core mission, such as the life sciences. Through the laboratories, DOE supports the technical staff to maintain the facilities and enable access to the facility for the broader S&T community.

C. Purpose of the National Laboratories

The 16 FFRDC laboratories are required to perform activities that cannot be accomplished as effectively by the private sector or academia.[10] Recognizing that both academia and industry can conduct R&D, the Commission believes the National

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[7] Certain of the laboratories serve not only to pursue the DOE nuclear weapons mission, but also to advance the national-security interests of the U.S. by serving other agencies in addition to DOE, principally Department of Defense, Department of Homeland Security, and the Intelligence Community.

[8] DOE, *Strategic Plan, 2014-2018*.

[9] In FY 2011, DOE was responsible for $2.61 billion of the total $5.53 billion of Federal funding for physical sciences research. National Science Foundation (NSF), National Center for Science and Engineering Statistics, *Federal Funds for Research and Development (FY 2010– FY 2012)* (Arlington, VA: NSF, 2014), Appendix Table 4-37.

[10] An FFRDC meets some special long-term research or development need which cannot be met as effectively by existing in-house or contractor resources (48 C.F.R. § 35.017). Though FFRDCs are prohibited from competing with non-FFRDCs, they may accept work from organizations other than the sponsor so long as permitted in their sponsoring agreement (48 C.F.R. § 35.017-1).

Laboratories should focus on conducting mission-driven science, including classified and high-risk, potentially high-reward research, emergency response, and large, long-term, multidisciplinary research projects.

> The Advanced Simulation and Computing (ASC) Program instituted by DOE's Defense Programs in the mid-1990s is a cornerstone of the science-based nuclear stockpile stewardship program. As part of the mission to extend the lifetime of nuclear weapons in the stockpile, ASC simulations are central to national security and allowed the shift to computational surrogates for nuclear testing. This development drove substantial acceleration in advancing high-performance computing, modeling, and simulation well beyond the weapons program and DOE. NNSA laboratories now house some of the world's fastest supercomputers. ASC tools are currently used for other vital missions, including nuclear nonproliferation, emergency response, and nuclear forensics, as well as purely civilian applications that require high-speed computation. (http://nnsa.energy.gov/asc)

1. Support of DOE

DOE relies on the laboratories to perform research they are best positioned to conduct relative to other performers. The laboratories primarily perform mission-driven science. The research at each laboratory generally extends beyond the primary mission of its stewarding office. Most laboratories obtain funding from multiple offices to perform research in support of multiple mission areas. In performing research for the national security mission, the laboratories often conduct projects that are classified. These mission-driven projects must limit the number of people with access to sensitive information, which precludes an open proposal system. Also in support of mission-driven science, the National Laboratories are able to pursue high-risk, potentially high-reward research which the Commission has been told often begins with laboratory directed research and development (LDRD) funds.

The DOE laboratories are able to conduct coordinated efforts in support of national needs through their networked structure and integrated research platform. Researchers housed within one National Laboratory collaborate on large, long-term, multidisciplinary projects with relative ease due to co-location and the mission-driven aspect of their work. In addition, large collaborative projects also occur across the laboratory complex, either organized by the DOE offices or individual laboratories. For example, Lawrence Berkeley, Brookhaven, and Fermilab have played major roles in guiding and assisting the technical development of the upgrade to the Linac Coherent Light Source at SLAC.

After the April 2010 Deepwater Horizon oil spill, more than 200 researchers from multiple DOE laboratories provided support through real time analysis, technical input, and oversight. The laboratory personnel shared expertise in stress analysis, fluid flow, advanced diagnostics, and geologic modeling, and assisted in determining the best method for containing the spill. (Hruby 2011)

Because the National Laboratories are a national S&T asset, the government can call upon them to employ their capabilities to respond to emerging threats in addition to the mission-driven nuclear response teams operated out of the national security laboratories. For example, the National Atmospheric Release Advisory Center[11] was activated after an underground fire and radiological release of isotopes of plutonium (Pu) and americium (Am) at the Waste Isolation Pilot Plant in February 2014 and it tracked releases from Fukushima Daiichi Reactors after the nuclear disaster in 2011. The laboratories also provided critical assistance in response to the outbreak of the Ebola virus in West Africa beginning in 2014.

The Commission endorses DOE's current strategic objectives to coordinate and improve its emergency response capabilities.[12] The Commission urges the DOE to continue to sustain these efforts and to better communicate the laboratories' successes.

2. Support of the Broader Science and Technology Community

The purpose of the laboratories extends beyond solely serving the needs of the DOE. The assets and capabilities at the National Laboratories benefit the entire science and technology community. The laboratories perform critical tasks in support of other Federal agencies, collaborate extensively with academia, partner with industry, and maintain user facilities for the entire S&T community, domestically and abroad.

The National Laboratories support a broad range of Federal agency missions, beyond their core activities for DOE. For example, they serve a vital role enabling the Department of Defense, Department of Homeland Security, Department of State, the Intelligence Community, and others to meet their missions.

NREL is developing a transportable system prototype for the Consolidated Utility Base Energy (CUBE) project for the U.S. Army. The power interface unit offers a containerized and highly mobile energy system that integrates standard generators, photovoltaics, and battery and grid power, which can be deployed at forward operating bases. CUBE is in the prototype phase and being fully tested to validate its performance, reliability, and projected fuel savings. (http://www.nrel.gov/esi/research_integration_wyle.html)

[11] "National Atmospheric Release Advisory Center (NARAC)," *Lawrence Livermore National Laboratory*, last modified September 14, 2012. https://narac.llnl.gov/.

[12] By the end of FY 2015, DOE expects to create an "Energy Incident Management and Response Council" to coordinate the Department's emergency response capabilities.

Through research collaborations, academics can connect to mission-oriented projects and work with interdisciplinary research teams. National Laboratories provide university researchers access to scientific facilities and unique equipment that are not available elsewhere. Every year tens of thousands of researchers use DOE user facilities, which include high performance computers, accelerators, colliders, light sources, neutron sources, and nanocenters. The laboratories also serve an important educational function through advanced training and continuing education of students and faculty.

In 2014 researchers led by Ilme Schlichting of the Max Planck Institute for Medical Research in Heidelberg, Germany, used the Linac Coherent Light Source X-ray free-electron laser at SLAC to generate a complete three-dimensional model of the protein lysozyme without any prior knowledge of its structure. This was a successful demonstration of a new technique for determining, from scratch, biological structures that form crystals too small for analysis with conventional X-ray sources. This could have far-reaching implications by potentially providing new targets for drug development. (http://science.energy.gov/bes/highlights/2014/bes-2014-10-k/)

As national centers for large scale, multidisciplinary research and development, the National Laboratories often advance objectives the private sector is unwilling or incapable of addressing. To facilitate adoption of these technological advancements by the market, the laboratories disseminate their knowledge to industry through research partnerships or direct transfers of intellectual property.

Lawrence Berkeley developed solid nanostructured polymer electrolyte for rechargeable lithium batteries and licensed the technology to start-up company Seeo, Inc. The technology is enabling development of a solid-state rechargeable lithium battery with the potential to improve the storage capability, safety and lifetime of rechargeable batteries for use in electric and hybrid vehicles, cell phones, laptops, and medical devices. These batteries are much safer because they lack the reactive and flammable materials of conventional lithium ion batteries, and they resist dendrite growth, a factor that has stalled commercialization of rechargeable batteries. Seeo was founded in 2007 and now has funding from several top Silicon Valley venture firms, including $17 million from Samsung Ventures. (Tilley 2014)

The Commission believes the scientific advances generated by the DOE laboratories translate into forces for economic growth. As such, the Department as a whole should develop a consistent positive stance concerning the National Laboratories' role in economic development. Currently, the transfer of research from laboratories to industry is inconsistently implemented across the complex and inconsistently supported within DOE. To be seen as a high priority objective by the laboratories, all DOE offices must commit to technology transfer and partnering with industry. Best practices among the laboratories should be shared and adoption encouraged by the DOE. Additional insights into effective policies and practices for working collaboratively with industry and for transferring know-how and technologies from the laboratories to industry can be gained from those universities with a history of productive industry partnerships and other organizations, such as the Fraunhofer Institutes, which have industry relationships deeply embedded in their mission. While technology transfer should not be viewed as the exclusive mission of the laboratories, it is a critically important part of their mission.

D. Relationship between DOE and the National Laboratories

While the relationship between DOE and its laboratories varies depending on the different program office stewards, processes, and mission objectives, the FFRDC model is the central element.

1. Importance of FFRDC Construct

The Federal Acquisition Regulation and Department of Energy Acquisition Regulation outline the requirements of an FFRDC, which sets the foundation for the relationship between the FFRDC and its sponsor.[13] FFRDCs must:

- meet a special long-term government R&D need that cannot be met as effectively by the government or the private sector;
- work in the public interest with objectivity and independence, and with full disclosure to the sponsoring agency;
- operate as an autonomous organization or identifiable operating unit of a parent organization;
- preserve familiarity with the needs of its sponsor(s) and retain a long-term relationship that attracts high-quality personnel; and
- maintain currency in field(s) of expertise and provide a quick-response capability.

The FFRDC construct is especially important to the laboratories' operation and success because the exemption from civil service regulations provides the flexibility necessary to attract leading technical and scientific talent; enables the ability to work closely with the government sponsor on future plans to create, align, and ensure the current and long-term relevancy of the laboratory; and provides the ability to work with others beyond DOE, on a non-interference basis, thereby leveraging knowledge and resources to advance missions and increase impact. FFRDCs are still subject to budgetary controls from both the sponsoring agency and Congress.

In general, FFRDCs must provide continuity, adaptability, and objectivity. Table 2 details how these benefits to the sponsoring agency translate to FFRDC capabilities.

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[13] Federal Acquisition Regulation, 48 C.F.R. § 35.017 (2014); Department of Energy Acquisition Regulation, Subpart 970.35 (2013).

Table 2. Value of the FFRDC Relationship

Benefit to Sponsor	Definition	FFRDC Capability
Continuity	Uninterrupted, consistent support based on a continuing relationship	Comprehensive knowledge of sponsoring organization's needs
		Institutional memory regarding mission, culture, expertise, and issues of enduring concern to the sponsor
Adaptability	Response to emerging needs of sponsors and anticipation of future critical issues	Quick response for short-term assistance to sponsors for urgent and high-priority requirements
		Personnel flexibility for workforce scale-ups or reductions on short time scale
		Link between sponsor offices and programs*
Objectivity	Thorough, independent analyses to address complex technical and analytical problems	Freedom from conflicts of interest and dedication to the public interest
		Independence from commercial, shareholder, political, or other associations
		Broad access to sensitive government information
		Absence of institutional interests that could lead to misuse of information

* For example, Argonne's battery program receives funding from both SC and EERE. Argonne has created a cohesive research program linked funding from SC for basic science and from EERE for applied science.

The M&O contract enables a sponsoring agency to enter into agreements with non-government entities that use their own capabilities for day-to-day operations and support functions, while drawing upon the parent organization's expertise when appropriate. In theory, the Federal sponsor uses oversight, annual evaluation, award fees, and potential recompetition of contract as mechanisms for ensuring that the performance by an FFRDC meets the needs of the government sponsor and that the capabilities continue to align with the sponsor's mission. The model relationship is not intended to involve many stages of approval or control of the laboratory by the sponsoring agency. Other variations of the contract, such as a Cooperative Agreement or a hybrid approach, are under evaluation by DOE and the laboratories and may prove valuable in restoring the DOE-laboratory relationship to its intended ideal.

Ideally, the laboratory as an FFRDC should function as an independent, long-term, trusted advisor and honest broker. This construct is important because it provides for the long-term continuity of missions and core capabilities that enable DOE to address major national challenges. Laboratories are able to serve as strategic advisors and partners to government, with access beyond that of a typical contractor, to bring the best ideas forward to inform program directions and therefore strengthen the plans for national programs. The laboratory is answerable only to the government customer and has no vested interest in particular technologies or solutions. To achieve this ideal, the FFRDC must trust that the sponsoring organization values its role. In turn, the government must trust that the FFRDC is acting as a disinterested, supportive party. These behaviors make it possible to build a partnership based on mutual trust.

2. Effective DOE Stewardship

Both the FFRDC and the oversight agency have certain responsibilities to ensure a successful relationship. As oversight agency of the National Laboratories, the DOE must define its own missions, provide work and funding to laboratories, determine desired outputs, oversee the laboratories, and communicate successes (or failures) to external stakeholders, including Congress. The FFRDCs, in turn, have a responsibility to execute scientific and technical work and manage the day-to-day business operations of the laboratories. Certain tasks are under the purview of both parties; strategic planning for the laboratories and the DOE are best accomplished jointly.

One of the Department's most critical roles as a steward is to develop strategic plans in consultation with the laboratories. Strategic direction must be developed for the DOE, the laboratory complex as a whole, and for individual laboratories. Strategic review, planning and implementation ensures alignment between laboratory and Department priorities, appropriate assignment of responsibilities across research programs and National Laboratories, and sufficient levels of collaboration with external parties, including academia and industry. As a steward of the 17 National Laboratories, the DOE is also responsible for evaluating the quality of research programs and ensuring each laboratory receives sufficient resources to maintain its capabilities. These issues will be discussed further in Chapter 4 of this report.

E. Summary Observations

The intent is for the DOE and its National Laboratories to work together to fulfill the Department's missions. As discussed in subsequent chapters, however, the actual operations of the laboratories can depart significantly from the model described here.

Based on its work to date, the Commission observes:

- The National Laboratories provide critical capabilities and facilities in service of DOE's mission and the needs of the broader national S&T community and the nation as a whole. The National Laboratories do this both as individual centers of excellence around the country and as a network of laboratories that often work in concert to achieve their missions.

- The mission of the National Laboratories includes providing vital resources and partnership opportunities to the nation's universities, private sector companies, and other technology and R&D organizations.
- The technology transfer role of the National Laboratories is very important for the nation's innovation and competiveness.
- All of the National Laboratories, save one, are run by non-governmental organizations as FFRDCs. That relationship is designed to allow expert organizations to manage the laboratories and to be accountable for laboratory performance under the overall direction of DOE. When the FFRDC model functions properly, it provides significant technical and management benefits to both the DOE and the laboratories. The M&O contracting approach, as originally developed, is designed to enable the National Laboratories to retain an exceptionally skilled workforce, be agile in shifting resources to new areas as needs change over time, and utilize the best management practices from the contracting organizations.

3. Major Recurrent Themes from Past Reports (and the lack of meaningful change)

A. Introduction

The Commission recognizes that an abundance of studies focused on DOE mission and management have been conducted by various external commissions or panels over the past two decades. This Commission's Phase 1 effort falls within the context of no less than four recently released studies specific to DOE or NNSA.[14] The Commission is therefore concerned about the steady accumulation of lengthy reports with different scopes, diverse objectives, and various political drivers. Despite the extensive examination of the issues, none of these reports has led to the comprehensive change necessary to address the well-documented, persistent challenges confronting the Department and its laboratories.[15] The Commission's approach has included in-depth analysis and use of previous studies.

The Commission's charge is distinct relative to most other studies in its review of the effectiveness of all 17 of the DOE laboratories, including their alignment with DOE's strategic priorities; their unique or duplicative missions and core capabilities; and their ability to evolve, plan, and prepare for the future. Of the reports the Commission reviewed, only the 1995 Galvin Report, *Alternative Futures for the Department of Energy National Laboratories*, and the 2013 National Academy of Public Administration (NAPA) report, *Positioning DOE's Labs for the Future: A Review of DOE's Management and Oversight of the National Laboratories* covered all of the DOE

[14] Congressional Advisory Panel on the Governance of the Nuclear Security Enterprise, *A New Foundation for the Nuclear Security Enterprise*; National Research Council (NRC), *Aligning the Governance Structure of the NNSA Laboratories to Meet 21st Century National Security Challenges* (Washington, DC: National Academies Press, 2015); Secretary of Energy Advisory Board (SEAB), *Interim Report of the Task Force on Nuclear Nonproliferation* (Washington, DC: DOE, 2014); NRC, *Peer Review and Design Competition in the NNSA National Security Laboratories* (forthcoming).

[15] While not instigating Department-wide reform, these earlier reports have had some influence on important elements of the Department's mission. For example, the Foster Panel reports positively impacted the technical processes relevant to certification of the nuclear weapons stockpile and the Blue Ribbon Commission on the Use of Competitive Procedures for Department of Energy Laboratories, in part, catalyzed important improvements to the evaluation processes adopted by the Office of Science beginning in 2004. See Panel to Assess the Reliability, Safety, and Security of the United States Nuclear Stockpile ("Foster Panel"), *FY 2001 Report of the Panel to Assess the Reliability, Safety, and Security of the United States Nuclear Stockpile* (Washington, DC: 2002), 2 and 23–24; and Blue Ribbon Commission on the Use of Competitive Procedures for Department of Energy Laboratories, *Competing the Management and Operations Contracts for DOE's National Laboratories* (Washington, DC: DOE, 2003), 17.

laboratories in such a sweeping fashion. The former was more aligned with both phases of the Commission's charge, while the latter focused more heavily on specific management elements encompassed by Phase 2. Of note, despite being almost 20 years apart and having different emphases, some of the findings of these two reports are remarkably similar to each other with respect to the lack of a strategic, integrated "laboratory system" approach and the breakdown of the FFRDC model. This latter issue is associated with highly compliance-focused government oversight, which has negative implications for the scientific enterprise, as subsequently discussed in more detail.[16]

Each of the studies conducted since the Galvin Report has had a different scope or focus related to the mission, management, and future of the National Laboratories. Not unlike the current Commission's study, previous studies were catalyzed by a specific issue of the time, such as mission execution, security breaches, and budgetary concerns. Most of the studies to date have focused on the nuclear weapons mission and its associated laboratories or production sites, but even the importance of the weapons mission has, at times, yielded to overarching concerns regarding the management of the laboratories or the effectiveness of security within the Department.

In the late 1990s, mounting concerns regarding the management of the weapons enterprise, combined with security scandals and allegations of espionage,[17] culminated in Congress establishing the NNSA as a "separately organized" entity within the Department of Energy.[18] However, this change has done little to address the enterprise's challenges in mission execution or its significant failings in program management and security, major concerns highlighted by studies prior to NNSA's establishment.[19] As the most recent study on NNSA, *A New Foundation for the Nuclear Enterprise*, noted, the

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[16] SEAB, *Alternative Futures for the Department of Energy National Laboratories* (Washington, DC: DOE, 1995), 6; and the National Academy for Public Administration (NAPA), *Positioning DOE's Laboratories for the Future: A Review of DOE's Management and Oversight of the National Laboratories* (Washington, DC: NAPA, 2013), 13, 23 and 75.

[17] Concern surrounding the nuclear weapons mission were encapsulated by the first Foster Panel Report: Panel to Assess the Reliability, Safety, and Security of the United States Nuclear Stockpile, *FY 1999 Report of the Panel to Assess the Reliability, Safety, and Security of the United States Nuclear Stockpile* (Washington, DC: 2000). Fears of Chinese espionage were advanced by the so-called Cox Commission Report (U.S. House of Representatives Select Committee on U.S. National Security and Military/Commercial Concerns with the People's Republic of China, *Final Report* (Washington, DC: 1999)). Laboratory security came to the fore in President's Foreign Intelligence Advisory Board (PFIAB) report entitled *Science at its Best, Security at its Worst: A Report on Security Problems at the US Department of Energy* (Washington, DC: 1999). All this was in the midst of a scandal surrounding Wen Ho Lee, a Taiwanese-born scientist at Los Alamos National Laboratory who was accused of espionage ("Trade Secrets," *The Economist*, February 7, 2002. http://www.economist.com/node/975548).

[18] National Nuclear Security Administration Act (Title XXXII of the National Defense Authorization Act for Fiscal Year 2000, P. L. 106-65).

[19] These include the 1999 Chiles Commission, the 2000 Foster Panel, and the 1999 PFIAB.

"unmistakable conclusion is that NNSA governance reform, at least as it has been implemented, has failed to provide the effective, mission-focused enterprise that Congress intended."[20] Although focused primarily on NNSA, the report noted that there are five systemic disorders that permeate the Department's culture and corresponding management challenges that must be addressed to achieve effective and efficient mission execution.[21]

Many of the reports, although heavily focused on the NNSA, emphasize that strategic priority setting and enforcement remain weaknesses within DOE. Effective execution of the mission is frequently hindered by problems in contractual oversight, unclear roles and responsibilities and the erosion of the trust upon which the FFRDC model is based. The reports that underscore ineffective establishment and enforcement of mission priorities suggest that this tendency is a result of inadequate planning and program management throughout the Department. Effective resource management is stymied by budgetary fragmentation, which is further aggravated by excessive costs for compliance-focused processes and duplicative oversight. These reports also make evident the lack of effective planning and program management capabilities with respect to long-term human capital and facility and infrastructure needs.[22]

Overall, the discontinuities among the previous reports on DOE largely stem from the scope and particular focus of each report. Despite this diversity in scope, there is remarkable convergence regarding the challenges that continue to plague the Department. Moreover, this convergence gives rise to recurring recommendations designed to address the identified challenges. Despite the recurrence of the same themes and the strength of the recommendations to help resolve the challenges they evoke, few reports have brought about the enduring, positive change intended.

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[20] Congressional Advisory Panel on the Governance of the Nuclear Security Enterprise, *A New Foundation for the Nuclear Security Enterprise*, x.

[21] The five disorders identified by the Nuclear Security Enterprise Governance Panel include: (1) the loss of sustained national leadership focus and priority, starting with the end of the Cold War; (2) inadequate implementation of the legislation establishing NNSA as a separately organized subelement of DOE; (3) the lack of proven management practices; (4) dysfunctional relationships between the government and its M&O site operators, and; (5) insufficient collaboration with DOD customers. Ibid, 6.

[22] For example, the reports focused on the weapons program couch this as stewardship readiness/responsiveness. See successive Foster Panel Reports from FY 1999, 2000, and 2001. The S&T reports focus on the multi-faceted nature of the mission or the importance of LDRD and want the laboratories to be given more discretion in setting the priorities. See NRC, *Managing for High Quality of Science and Engineering at the NNSA National Security Laboratories* (Washington, DC: National Academies Press, 2012). The security studies note the lack of long-term planning for tools and technologies to adequately address security and CI. PFIAB, *Science at its Best, Security at its Worst* (Washington, DC: PFIAB, 1999) and Richard Mies, *NNSA Security: An Independent Review* (Washington, DC: Sage/LMI, 2005).

B. Major Recurring Themes Produce Little Change

Even at this preliminary stage of its efforts, the Commission observes recurring themes that have emerged from its review of prior reports, the public meetings, and its laboratory visits to date.

Several reports describe a dysfunctional relationship between DOE and its laboratories, generically couched as the erosion or loss of the mutual trust required by the FFRDC model. Based on our initial observations, this difficulty is not uniformly experienced across the laboratories, and its severity varies widely. The primary factors affecting severity of the challenges faced are which office within DOE acts as the laboratory's sponsor and the role assumed by the leadership and personnel at each laboratory's field office. The operational manifestations of an eroded FFRDC model are generally characterized by DOE's "micromanagement" of the laboratories and a focus on compliance as opposed to mission outcomes. This is exacerbated by confused roles and responsibilities in conjunction with ambiguous or conflicting DOE Orders and Directives which compel a focus on transactional compliance rather than effective risk management.[23] This cursory overview of recurring themes and their interrelationship has shaped the Commission's understanding and its approach. In addition, concerns over the lack of impact from all these studies weighed heavily in the Commission's considerations regarding its focus and objectives in Phase 2.

1. Broken Trust Undermines Fulfillment of the FFRDC Promise

Previous studies repeatedly underscore the breakdown of the FFRDC model as the fundamental impediment to a productive relationship between DOE and its laboratories. As stated previously, the FFRDC model is based on the premise that these entities act as "trusted advisors" to their government sponsors; the ideal relationship is that the government sponsor defines "what" problem or challenge needs to be addressed and the FFRDC delineates "how" to work towards a solution. Instead DOE engages in prescriptive management and focuses on transactional compliance. This has resulted in the imposition of additional cost due to greater oversight and in a deleterious environment for innovation.[24] The Galvin Report found that "increasing overhead cost, poor morale and gross inefficiencies as a result of overly prescriptive congressional management and excessive oversight by the Department" and an "(in)ordinate internal

[23] See NRC, *Managing for High Quality of Science and Engineering at the NNSA National Security* Laboratories, 4–5; and Congressional Advisory Panel on the Governance of the Nuclear Security Enterprise, *A New Foundation for the Nuclear Security Enterprise*, 23–25.

[24] See, for example, Congressional Advisory Panel on the Governance of the Nuclear Security Enterprise, *A New Foundation for the Nuclear Security Enterprise*, 5.

focus at every level of these laboratories on compliance issues and questions of management processes…takes a major toll on research performance."[25]

This theme of overly prescriptive management and emphasis on transactional compliance can be found in almost every report over the past two decades and represents the antithesis of how the FFRDC model was designed to operate. For example, in a detailed depiction of specific management processes and the Department's approach to oversight, the 2013 NAPA study concluded that a successful transition to a more outcome-based evaluation approach would require that DOE staff in both headquarters and the site offices "change the way they conduct business." Such a transition would also require that DOE staff "step back from overseeing and evaluating the labs at the transaction level and embrace a systems approach to managing the labs…"[26] Prescriptive management and a focus on tactical compliance rather than outcomes are but two manifestations of the breakdown in the FFRDC construct. Other examples surface in numerous reports and will be the subject of more detailed examination by the Commission in Phase 2, as outlined in the next subsection.

2. Broken Trust Fuels Operational Impediments

In an attempt to identify the most important issues for Phase 2, the Commission categorized recommendations from all the major studies, as well as relevant Government Accountability Office (GAO) and DOE Office of the Inspector General (OIG) reports from 1995 to 2014. The recommendations were then prioritized, based on frequency of the recommendation; potential impact on the enterprise; DOE-wide or NNSA specific; range of actors required for implementation (Office of Management and Budget [OMB], Congress, DOE, etc.); and unambiguous regarding the desired outcome.

The following five issues stood out in terms of the criteria (with actors involved in parenthesis):

- Budget atomization, which impedes flexibility and innovation (requires OMB, congressional, and DOE action);
- DOE Orders and Directives, which drive transactional, compliance-focused behavior at high cost and impede innovation (requires DOE action with the Defense Nuclear Facilities Safety Board as a significant "stakeholder");
- Excessive and redundant audits and inspections, which partially result from DOE Orders and Directives, but represent an issue broader than just DOE (requires multiple actors beyond DOE: non-DOE OIG, GAO, Defense Nuclear

[25] SEAB, *Alternative Futures for the Department of Energy National Laboratories,* 6.

[26] NAPA, *Positioning DOE's Laboratories for the Future: A Review of DOE's Management and Oversight of the National Laboratories,* 75.

Facilities Safety Board, Occupational Safety and Health Administration, state regulatory agencies, etc.);

- Enterprise-wide information management lacks comprehensive, reliable data, which hinders planning for workforce needs, preparing budget requests, identifying costs for activities, and ensuring validity of cost estimates (requires DOE and M&O contractor action); and
- Confused roles, responsibilities, accountability, and authority stymie a "line management" approach to NNSA's mission execution, frequently with operational support elements (safety, security, and environment) skewing incentives toward delay or excessively conservative approaches to risk (requires DOE action, both headquarters and site office).

The first three of these issues fall readily under the rubric of "transactional compliance" and could be viewed as specific, but interrelated, manifestations of a tarnished (or forgotten) FFRDC model. The impacts of these issues, individually and combined, include a further erosion of the trust requisite for proper functioning of the FFRDC construct, an assumed cost for compliance that detracts from science, and the opportunity costs to the mission. The Commission is taking up the fourth issue regarding enterprise-wide data as it pertains to laboratory overhead rates; these rates are a partial reflection of the transactional tasks requisite for compliance and highly relevant to the Commission's charge. The final issue is handled in a comprehensive fashion by the recent report *A New Foundation for the Nuclear Security Enterprise*.[27] The Commission fully endorses that report and urges swift action to clarify the roles, responsibilities, accountability and authorities throughout the Department, whether or not Congress legislates the statutory changes called for by the report.

The first four issues will be investigated in greater detail during Phase 2 of the Commission's work. Although earlier reports have referenced these problems and have argued for their resolution, the Commission believes that through the collection of the relevant data and extensive examination of these issues, it can proffer comprehensive, specific recommendations that will have an enduring and positive impact on DOE's management of its laboratories. Resolving these challenges also would help rebuild the relationship requisite for proper functioning of the FFRDC model.

C. Why Past Reports Have Failed to Bring About Change

Past reports have failed to catalyze needed changes for a variety of reasons. One obvious reason is that many of the recurring themes are systemic problems, both beyond

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[27] Congressional Advisory Panel on the Governance of the Nuclear Security Enterprise, *A New Foundation for the Nuclear Security* Enterprise, 21–35.

and within the DOE itself. As noted in the listing of entities relevant to the compliance issues outlined above, some of the Department's enduring challenges can be addressed only through a coordinated effort on the part of Congress and the Department's leadership, at a minimum. As the foremost historic example, the establishment of NNSA underscores that legislation is often a blunt instrument and that successful outcomes hinge on implementation.

A second prominent problem is lack of awareness or understanding of the DOE's missions and the role of the laboratories in our nation's S&T endeavors. This is true for a broad swath of the general public as well as for Congress. Congressional attention on DOE frequently focuses on either a parochial issue or is embedded in larger divisive debates such as the role of the Nation's nuclear deterrent in today's international security environment or the role of government in advancing energy technology.

Another prominent problem, mentioned previously, is that despite the recurrence of themes and recommendations, the diverse drivers for these reports have led to voluminous, sometimes duplicative, assessments. However, there is still no persistent mechanism for assessing the implementation of appropriate recommendations or metrics to measure improvements for actions taken in response to any given report. Lastly, the rotating leadership of the Department requires institutionalizing those high-level activities that prove successful in remedying major problems. The Commission is mindful of several positive steps taken by the current Secretary and will examine possible ways to institutionalize these activities in its final report.

The Commission is intent on ensuring its final recommendations are sufficiently detailed and specify every party accountable for any action required. To the extent feasible, the Commission will also offer approaches to measure successful implementation of each recommendation with the hope of avoiding other pitfalls regarding report recommendations; namely, lack of accountability for implementation and misunderstandings with respect to the outcome sought. To achieve this objective the Commission will be examining each of the issues listed in the previous section to identify specific reasons for the failure to act on them or why any earlier attempts at implementation failed. The Commission aims to apply any lessons learned from this exercise to inform its own approach to the recommendations put forward in its final report.

D. Summary Observations

Over 50 prior studies and reports published over the past 40 years detail shortcomings in the relationship between the DOE and its laboratories. Though the mandates for each assessment diverge in scope, objectives, and the members charged to fulfill them, they present a strikingly consistent pattern of criticism and recommendations for improvement. These themes include:

- Micromanagement of the laboratories by DOE headquarters and site offices.
- Excessive budget controls, which restrict the laboratories' abilities to manage resources flexibly to achieve mission responsibilities effectively and efficiently.
- Oversight practices that involve excessive numbers of site inspections, transactional oversight, and burdensome data calls.
- Past recommendations for improvement have, for the most part, had limited impact, as demonstrated by the fact that the same problems recur in report after report.
- Because root causes of these problems are hard to ascertain, recommendations from past commissions have proven difficult, if not impossible, to implement.
- There is no standing body, either within DOE or outside, to advocate for implementation, perform systematic assessments, and evaluate progress over time. Simultaneously, DOE has no institutionalized internal mechanism to assimilate, assess, and act on appropriate recommendations.

In Phase 2 of its study, the Commission will explore options regarding future commissions, their mandates, frequency and makeup, and a systematic way to monitor and evaluate progress. Also, as part of its lessons-learned exercise regarding the failed implementation of past recommendations, the Commission will evaluate what institutional mechanisms might best address this shortfall.

4. Performance in Support of DOE

As the steward of the 17 National Laboratories, DOE is responsible for aligning work with mission priorities, ensuring the quality of the research and research programs, monitoring for duplication, and providing sufficient resources to allow the laboratories to execute the Department's missions. This chapter provides observations on how well the Department is stewarding its laboratories and on the ways in which the National Laboratories, both individually and as a complex, support DOE.

A. DOE and Laboratory Strategic Planning

One of the Department's most critical roles as a steward is to provide strategic direction to the laboratory complex. Strategic review, planning, and implementation are essential for alignment among the complex, the laboratories' sponsors, and the Department's priorities, but few processes exist that provide this type of strategic direction to the laboratory complex as a whole. The exceptions are certain topic-based initiatives, such as Grid Modernization, the National Nanotechnology Initiative (NNI),[28] the supercritical carbon dioxide program, and subsurface science research.

The Commission strongly believes that strategic planning for both the Department and the laboratories is best accomplished jointly, with DOE and its laboratories working together. The level of laboratory involvement in DOE strategic planning varies by office. For example, the DOE Office of Science (SC) laboratories are involved in SC's Laboratory Strategic Planning process, described in more detail below, but they may be absent from broader discussions involving SC's overall direction, priorities, and funding levels. In contrast, the Office of Nuclear Energy (NE) is updating its R&D roadmap through a process that involves the deputies and representatives from all the National Laboratories. Idaho National Laboratory was responsible for collecting this input, which NE used to make its final decisions on the R&D strategic plan.

The consensus among current laboratory management is that Secretary of Energy Moniz is committed and taking steps to increase laboratory involvement in DOE's strategic planning. The Commission concurs with this assessment and notes, for example, the Big Ideas Summit, which involved the laboratories in a discussion of ways in which

[28] The NNI was, in fact, an interagency effort instigated by the Executive Office of the President. See National Science and Technology Council Committee on Technology Subcommittee on Nanoscale Science, Engineering, and Technology, *National Nanotechnology Initiative Strategic Plan* (Washington, DC: 2014).

their capabilities could help solve grand challenges. He has also been a strong supporter of the National Laboratory Directors' Council during his tenure, which has improved communication between the laboratories and DOE's senior management. In addition, Secretary Moniz has initiated complex-wide strategic planning through programmatic crosscuts. One key to the success of the crosscut initiative is the treatment of laboratories as partners in the strategic planning exercise. As experts in their fields, laboratory scientists and engineers have much to contribute to determining the most likely course of scientific and technological developments. The Commission believes that the Department urgently needs to institutionalize laboratory involvement in DOE strategic thinking in order to ensure a consistent and productive relationship between the laboratories and DOE management that is not subject to fluctuation as a result of changes in DOE's leadership.

B. Processes to Ensure Alignment of Research and Research Programs

SC has established effective formal processes to ensure proper alignment between the research being done at its laboratories, its research programs and the Department's missions and strategic priorities. These processes are used to both encourage and discourage the development of new technical capabilities. Alignment is assessed during the annual review process, which involves both the Laboratory Strategic Planning process and the Performance Evaluation and Measurement Plan (PEMP).[29] During the Laboratory Strategic Planning process, SC asks the laboratory leadership to define a long-range vision for their respective laboratories. This information provides a starting point for discussion about each laboratory's future directions, immediate and long-range challenges, and resource needs. DOE and the laboratory leadership settle on new research directions and the expected development or sustainment of capabilities. In addition, external advisory committees provide advice on establishing research and facilities priorities; determining proper program balance among disciplines; and identifying opportunities for inter-laboratory collaboration, program integration, and industrial participation.

An excellent example of this is the recent report spearheaded by SC's Office of High Energy Physics. In 2014 the Particle Physics Project Prioritization Panel (P-5), a subpanel of the High Energy Physics Advisory Panel (HEPAP), published a 10-year strategic plan for high energy physics in the United States.[30] The panel included leading experts in the field not only from the DOE laboratories, but also from universities and other laboratories in both the U.S. and abroad. This P-5 report showcases a unified,

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[29] The PEMP is described in more detail in section 4.C.1 below.

[30] Particle Physics Project Prioritization Panel (P-5), *Building for Discovery: Strategic Plan for U.S. Particle Physics in the Global Context* (Washington, DC: DOE, 2014).

community-led effort to communicate realistic priorities to the SC. It was the product of a year-long community-wide study and recommends a prioritized and time-ordered list of facility upgrades and research projects that address five scientific drivers. The SC program directors are in the process of implementing the report's recommendations by phasing out certain projects and initiating funding for others.

NNSA's planning processes are unavoidably more complex because there are few technically competent reviewers outside the weapons complex capable of contributing effectively to the strategic planning process. Each program office in NNSA reviews its strategic plans with the laboratories. For example, Defense Programs (NA-10) coordinates the Stockpile Stewardship and Management Plan, a congressionally mandated 25-year program and capabilities-focused document that is a collaborative effort involving all the sites and stakeholders.[31] Semiannually, the Defense Nuclear Non-Proliferation Office (NA-20) uses an Assistant Laboratory Director "science council" with all the laboratories to discuss strategic direction and core capabilities that are critical to the NA-20 mission. However, since these reviews are program based, the effectiveness at providing overall strategic direction to the three weapons laboratories remains unclear. NNSA has also recently instituted a process similar to the PEMP, but the NNSA process has focused more on operations than on strategic direction over the past several years.

According to interviewees, other offices rely on informal processes that can be effective for ensuring proper alignment between the laboratories and DOE. By co-locating about half of its staff in Idaho, NE has established daily communication with its laboratory. While this approach may not be practical for DOE's larger program offices (e.g., SC and NNSA), it appears to be effective for NE. Numerous interviewees stated that some kind of continuous dialogue between the laboratory and DOE Headquarters can be an effective alignment and planning mechanism, beyond what formal processes can accomplish. The effectiveness of informal processes may depend on the involvement of a relatively small number of participants. The NNSA Office of Counterterrorism and Counterproliferation (NA-80), for example, includes a small community of researchers and DOE staff, and its small size allows for frequent dialogue to control alignment and strategic direction.

[31] The Stockpile Stewardship and Management Plan's (SSMP) validity as an executable plan remains an issue of debate between the DOD customer and NNSA. See Congressional Advisory Panel on the Governance of the Nuclear Security Enterprise, *A New* Foundation *for the Nuclear Security Enterprise*, 12–14.

C. Processes to Ensure High-Quality Research and Research Programs

The SC has relatively mature processes in place for assessing the quality of the research being done by the 10 laboratories under its stewardship. The office also has numerous processes to assess the quality of the research portfolio in each of its programs. The processes in place at the other DOE program offices are not as mature, and interviewees suggested that the SC processes could be adopted by the other DOE program offices. For this reason, it is useful to look at the SC processes in more detail.

1. Office of Science Annual Review Process: Performance Evaluation and Measurement Plan (PEMP)

The SC conducts an annual evaluation of the scientific, technical, managerial, and operational performance of its 10 laboratories. This process is coordinated by SC's Office of Laboratory Policy on behalf of SC's Director. These evaluations provide the basis for determining annual performance fees and the possibility of winning additional years on the contract through an "Award Term" extension. They also serve to inform DOE decisions regarding whether to extend or to recompete the management and operating (M&O) contracts when they expire.

The current laboratory appraisal process started in 2006 and was designed to improve the transparency of the process, increase the involvement of the SC leadership, standardize the laboratory evaluation, and more effectively incentivize contractor performance by tying performance to fee earned, contract length, and publicly released grades.

The SC laboratory appraisal process uses a common structure and scoring system across all laboratories and is structured around eight performance goals, each of which is comprised of several objectives. The eight performance goals and objectives are given in Table 3.

Table 3. Eight Performance Goals and Objectives Used in the PEMP

Performance Goals	Objectives
1. Mission Accomplishment (Delivery of S&T)	• Impact (significance) • Leadership (recognition of S&T accomplishments)
2. Design, Construction and Operation of Research Facilities	• Design of Facility • Construction of Facility/Fabrication of Components • Operation of Facility (e.g., availability, reliability, and efficiency of facility) • Utilization of Facility to Grow and Support Laboratory's Research Base and External User Community

3. Science and Technology Project/Program Management	• Strategic Planning, Stewardship of Scientific Capabilities and Programmatic Vision • S&T Project/Program/Facilities Management • Communications and Responsiveness to DOE Headquarters
4. Leadership and Stewardship of the Laboratory	• Leadership and Stewardship of the Laboratory • Management and Operation of the Laboratory • Contractor Value-Added
5. Integrated Environment, Safety and Health Protection	• Worker Safety and Health Program • Environmental Management System
6. Business Systems	• Financial Management System(s) • Acquisition and Property Management System • Human Resource Management System and Diversity Program • Internal Audit, Information Management, Assurance, and Other Administrative Systems
7. Facilities Maintenance and Infrastructure	• Manage Facilities and Infrastructure (F&I) in a Manner that Optimizes Usage and Minimizes Life Cycle Costs • Plan for and acquire the F&I required to support future lab programs
8. Security and Emergency Management	• Emergency Management System • Cyber-Security and Protection of Classified and Unclassified Information • System for the Physical Security and Protection of Special Nuclear Materials, Classified Matter, and Property

Within each objective, the SC program offices and Site Offices can further identify a small number of notable outcomes that illustrate important features of the laboratory's performance. The performance goals, objectives, and notable outcomes are documented at the beginning of each year in the PEMP, which is appended to the laboratory's M&O contract.

At the conclusion of each fiscal year, the organizations that fund work at that laboratory evaluate the S&T performance of the laboratory (Goals 1–3 in Table 3). In addition to the SC science programs, SC solicits input from all organizations that spend more than $1 million at the laboratory. This input is weighted according to the dollars spent. Each Site Office evaluates the laboratory's performance against the M&O objectives (Goals 5–8). Site Offices and the SC program offices provide input regarding the contractor's performance with respect to Goal 4 to SC's leadership to determine the laboratory's score in this area. In determining these grades, the SC program offices and the Site Office consider the laboratory's performance against the notable outcomes, defined in the PEMP, as well as other sources of performance information that become available throughout the year. These sources might include independent scientific program and project reviews; external operational reviews conducted by GAO, DOE OIG, and other parts of DOE; and the results of SC's own oversight activities. The evaluation process concludes with meetings for all the performance goals, during which the various organizations involved report their proposed scores and work to ensure a consistent and fair approach across all ten SC laboratories.

The PEMP process uses a five-point grading system. The grade for each of the performance goals is based on a weighted computation of the scores of the individual performance objectives identified for each Goal. SC uses the resulting performance goal grades to create annual "report cards" for each laboratory that are publicly available on the SC website.

The Commission notes that other significant assessment activities also occur within the SC program offices. These reviews include division-led laboratory management reviews that provide strategic vision for the research programs, including discussion of topics for current and proposed white papers and related LDRD activities. They not only cover the status of each project, but also include relevant programmatic activities such as recruitment, infrastructure, equipment, and instrumentation. SC also carries out a triennial science/operational review of its user facilities, which is an essential part of the performance assessment of these facilities. Each review takes 2 to 3 days to complete, involves numerous subject matter experts, and considers the following key performance metrics:

- The number of unique users served;
- Facility operational hours and reliability;
- Number of peer reviewed publications;
- User satisfaction and staff morale;
- Environmental and health/safety factors;
- Effectiveness of Advisory Committees; and
- Strategic planning for the future.

2. Office of Science External Review Processes

Each of the programs within SC have established Advisory Committees to provide independent advice to the Director of SC regarding the scientific and technical issues that arise in the planning, management, and implementation of the programs. These recommendations include advice on establishing research and facilities priorities;

determining proper program balance among disciplines; and identifying opportunities for inter-laboratory collaboration, program integration, academic collaboration and industrial participation. The Advisory Committees include representatives of universities, research laboratories, and industries involved in energy-related scientific research. Membership of these committees is also increasingly including international participants. Particular attention is paid to obtaining a diverse membership with a balance of disciplines, interests, experiences, points of view, and geography.

The SC Director also charges the Advisory Committees to assemble Committees of Visitors (COVs) "to assess the efficacy and quality of the processes used to solicit, review, recommend, monitor, and document funding actions and to assess the quality of the resulting portfolio."[32] The national and international standing of the research are part of the evaluation. This review includes both awards and declinations for universities, National Laboratories, and industry. Every program must be reviewed by a COV at least once every 3 years. Each panel is made-up of scientists and research managers recognized to have significant expertise in the appropriate field. Although panel members are familiar with DOE research programs, a significant fraction of the COV members do not receive DOE funding. The COV prepares a report that is reviewed by the Advisory Committee, which may make modifications prior to acceptance. Following acceptance, the report is transmitted to the SC Director and released publicly. The Associate SC Director in charge of the program element under review must provide a response within 30 days of the acceptance of the report.

Another type of external review process used by the SC program offices is the Comparative Research Review. These reviews provide independent comparative evaluations of supported research activities as a means to ensuring the quality and impact of the science supported by SC. For example, in 2013 SC's Office of Nuclear Physics established a comparative panel review of research it supports in the fields of heavy ions, medium energy, nuclear structure and nuclear astrophysics, nuclear theory, and fundamental symmetries. The review provided important input to the Office of Nuclear Physics regarding the quality and balance of its research portfolio. It also helped establish a strategic vision for U.S. nuclear science developed in partnership with the broader research community.

3. Competitive Funding of Office of Science Programs

Peer review and competitive funding of research are essential for ensuring high-quality science and technology research. The SC makes extensive use of peer review to maintain the high quality of the research it funds. Its review methods, which closely

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[32] "Committees of Visitors," *DOE Office of Science*, last modified March 18, 2013, http://science.energy.gov/sc-2/committees-of-visitors/.

resemble the well-developed methods of NSF and NIH, take one of three forms: mail reviews, panel reviews, and site visits. Mail reviews are generally used for open solicitations in which proposals arrive throughout the year. Reviewers are usually given 6 weeks to review the proposal and return the review. Panel reviews are created for targeted solicitations when many proposals arrive simultaneously. Multiple panels of 10–15 people each convene in Washington, DC, to review the proposals and submit reviews. For a large solicitation, the total number of panelists at any given time can total in the hundreds. Site visits are coordinated for large group programs, such as National Laboratory efforts or large facility competitions. Researchers make presentations to the site visit team who then may interact with and ask questions of the investigators. The site visit team members then submit independent reviews to DOE. The Commission is currently gathering quantitative data to determine the percentage of DOE research funding that is awarded on a competitive basis.

4. Assessment Processes at Other DOE Program Offices

Those interviewed by the Commission generally agree that SC's processes for assessing the quality of both the research conducted by their ten laboratories and of the research portfolio in each SC program are far more mature than those in the other DOE program offices. For this reason, it is often suggested that the other DOE program offices adopt these processes. Some factors, however, necessarily limit the applicability of SC's processes to other programs. For example, because the research at the NNSA laboratories is often classified, there are far fewer investigators with the requisite technical capabilities and so there is inherently less competition. The classified nature of the work also affects NNSA's use of Advisory Panels and Committees of Visitors. Nonetheless, the SC processes have influenced other DOE program offices. For example, NE has adopted a PEMP-like process modeled after SC, but with greater emphasis on safety. Also, NNSA is working with SC to establish project assessment processes similar to those in SC's Office of Project Assessment. The Commission also notes that an ongoing National Academies study is currently reviewing peer review and design competition at NNSA's three national security laboratories (Los Alamos, Lawrence Livermore and Sandia).[33]

[33] Further information can be found at http://www8.nationalacademies.org/cp/projectview.aspx?key=49632.

D. Alignment with DOE's Objectives and Level of Duplication of Research

1. Alignment with DOE's Strategic Priorities

Research funded by the stewarding program office of the laboratory is likely aligned with the strategic priorities of the office and so will also be aligned with DOE's strategic priorities so long as the office itself is aligned with those priorities.[34] The question of alignment or misalignment usually arises when one considers research funding from other program offices within the Department, other Federal agencies, or other entities altogether. Like everything involving the laboratories, the magnitude of this issue varies when one looks at different laboratories across the complex. For example, over 97% of Fermilab's budget is provided by SC's Office of High Energy Physics, which enables a significant amount of control over its research activities by its stewarding office. On the other hand, only 58% of Sandia's funding originates from NNSA and only 20% of Pacific Northwest's funding comes from SC. The National Laboratories also have the authority to spend up to 6% of their funds on LDRD. Depending on the size of the laboratory budget, this amount can represent a sizable investment in new research areas.

The Commission notes that there are examples of the National Laboratories changing their research focus in response to changes in DOE strategic priorities, national needs or a changing research landscape. An excellent, and current, example is Fermilab's response to the P-5 Report mentioned earlier. As a result of the P-5 Report, Fermilab is moving away from accelerator-based high energy physics (most of which is now being done at CERN, the European Organization for Nuclear Research) and is focusing much of its research on neutrino physics using its accelerator complex. Despite this and other examples of changing focus in response to changing priorities or needs, there is at least one glaring example of an apparent misalignment between a program office and DOE's strategic priorities, and that is in the area of environmental remediation. A recent SEAB report stated that DOE has spent over $150 billion on environmental management (EM) and cleanup and is currently spending roughly $5–6 billion per year in this area.[35] At the same time, the current EM budget for technology development is only $13 million per year, despite the fact that there are many technical obstacles to the successful completion of the project. Given that the success of the cleanup effort will require significant new technology, the SEAB recommended that DOE increase its S&T investments for the EM cleanup program.

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[34] Issues related to program office alignment with DOE strategic priorities are outside the scope of the Commission's charge.

[35] SEAB, *Report of the Task Force on Technology Development for Environmental Management,* (Washington, DC: DOE, 2014).

Based on its observations so far, the Commission believes that for the most part the National Laboratories' research programs and capabilities are aligned with DOE's mission and strategic priorities, aside from the Environmental Management mission. As the Commission visits more laboratories during the second phase of its effort, additional data will be gathered.

2. Alignment with the Broader Science and Technology Enterprise

DOE is a steward of the important national assets and capabilities that exist at the National Laboratories. A crucial point is that these assets and capabilities benefit the entire science and technology community. The Commission notes that often when activities at the laboratories are perceived as "misaligned" with DOE strategic priorities, the activities do, in fact, align with the needs of this broader community, the strength of which is certainly of strategic importance to DOE, as well as the Nation.

A historical example involves DOE's work on the human genome. Los Alamos and other DOE laboratories were integral to the successful completion of the Human Genome Project. DOE originally announced its Human Genome Initiative in 1986 and was ultimately joined by the National Institutes of Health (NIH) in a combined project. Stemming from the laboratory's expertise in the biological effects of irradiation, Los Alamos had developed the capacity to isolate, clone, and package chromosomes into libraries and operated a public gene data bank. The Battelle Technology Partnership Practice estimated the economic impact of genomic research to be $796 billion, a return on investment of 141:1.[36] Despite the tremendous social, technological, and economic impact, DOE's involvement in the Human Genome Project is often criticized as "mission drift." The Commission notes, however, that Los Alamos's initial work was mission-related, and that while one might argue that the Human Genome Project should have been initiated by NIH, the fact is that the Nation is currently accruing the benefits of this effort in large part because DOE had the necessary capabilities to address this challenge.

Currently, tens of thousands of scientists utilize the user facilities at the National Laboratories each year, including thousands funded by the NIH and the National Science Foundation (NSF). Many DOE user facilities are oversubscribed, a sign of their critical importance to the broader research community and an argument for expanding, rather than contracting, their work in this domain. For example, according to Argonne, the Center for Nanoscale Materials accommodates roughly 70% of meritorious users and the Advanced Photon Source accommodates about 30%.

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[36] S. Tripp and M. Grueber, *Economic Impact of the Human Genome Project* (Battelle Memorial Institute, 2011).

Another example of the National Laboratories supporting a broader range of missions, beyond their core activities for DOE, involves their work for the Department of Homeland Security (DHS). DHS has authority equal to DOE's to request technical and scientific assistance from the National Laboratories in order to address specific DHS science and technology needs. In creating DHS, Congress intended that the new office should take advantage of existing facilities and capabilities, including the DOE National Laboratories, and saw no need to establish a new system of DHS laboratories.[37] The laboratories also serve a vital role enabling the Department of Defense, Department of State, the Intelligence Community, and others to meet their missions.[38]

The Commission believes the laboratories need some measure of flexibility to be able to pursue valuable research in service of the broader science and technology community, but the flexibility must be within reason. The Department, through its strategic oversight of the laboratories, should provide feedback when activities seem to veer too far from DOE's core mission. DOE must take care in its supervision, however, because relevance to mission often takes time to become apparent.

3. Appropriate Levels of Duplication

The Commission notes that competition and therefore a certain amount of duplication is integral to scientific advancement. Scientific progress is made through trial and error and the chance of success increases with the number of people who try different ideas and strategies. The reality of finite resources must, of course, also be recognized—the government simply cannot fund every idea in every field. In addition, spreading resources too thinly across too many researchers is inefficient. The Commission believes a balance should exist between allowing creativity and innovation to blossom and appropriately managing resources to maximize productivity. Resources should allow the maximum number of participants and different ideas to thrive during the genesis of a new field or technology. But once a specific scheme has proved superior to others, resources should be directed there. As such, DOE should give laboratories the flexibility to pursue new lines of inquiry using, for example, LDRD, so long as the funds align with mission priorities. The Commission feels that once research has matured beyond a certain threshold, the Department should then provide expert strategic oversight and guidance for

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[37] In addition to the equal access provision in the Homeland Security Act of 2002 regarding DOE laboratories, the Act also authorized the Secretary of Homeland Security, acting through the Under Secretary for Science and Technology, to establish one or more Federally Funded Research and Development Centers. DHS currently sponsors two of its own FFRDCs: the Homeland Security Systems Engineering and Development Institute and Homeland Security Studies and Analysis Institute. More information on the roles performed by these centers is available at: .http://www.dhs.gov/science-and-technology/ffrdcs.

[38] Support of other Federal agencies will be discussed further in Chapter 5.

the laboratories to coordinate and potentially consolidate their programs to achieve the most efficient use of resources.

An area in which the question of competition and duplication is more subtle involves the weapons work at NNSA's three national security laboratories. Since the cessation of nuclear weapons testing in the early 1990s, science-based stockpile stewardship has been necessary, which requires a certain level of "redundancy in approach" that entails a unique mix of competition, collaboration, and duplication. The Commission is aware of examples in which duplication and competition in the weapons complex have resulted in significant reductions in cost and schedule and, in some cases, reductions in size and weight of the weapon. Moreover, the fact that Los Alamos and Lawrence Livermore run different computer codes for verification of the readiness of the nuclear stockpile increases the confidence level of the program. A related issue is that esoteric scientific and technical skills are required at the NNSA laboratories. The necessary skill set is not taught in universities and it takes a long time to develop these core technical capabilities. The Commission strongly believes that these capabilities must be maintained for national security reasons. Nonetheless, it is important to continue to review the appropriate level of duplication/overlap of technical capabilities at the NNSA laboratories, and this question will be explored in more detail during Phase 2 of the Commission's efforts. The Commission also notes that the ongoing National Academies study is reviewing peer review and design competition at the three weapons laboratories.[39]

a. Large User Facilities

Because of the significant resources involved, the Department has developed processes for prioritizing user facilities[40] and avoiding duplicative facilities. These processes are often led by external topic-based advisory panels and involve multiple Federal agencies—for example, the Basic Energy Sciences Advisory Committee (BESAC)[41] and the previously noted HEPAP,[42] which reports to DOE and NSF jointly.

The success of these processes in managing large user facilities may be best illustrated by recent changes to DOE's thinking about new light sources. SC significantly amended its strategy for synchrotron light sources as a result of the BESAC report, *Future X-Ray Light Sources*. Similarly, after consultation with SC, SLAC modified its

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[39] Further information can be found at http://www8.nationalacademies.org/cp/projectview.aspx?key=49632.

[40] See Appendix G for more information on DOE user facilities.

[41] For more information see http://science.energy.gov/bes/besac/. DOE has not requested NSF's participation in BESAC, a fact which several interviewees criticized.

[42] For more information see http://science.energy.gov/hep/hepap.

plans for the Linac Coherent Light Source II (LCLS-II) to integrate new functionality; Argonne will incorporate diffraction limited storage ring technology into its Advanced Photon Source Upgrade (APS-U); and Lawrence Berkeley has terminated its proposed Next Generation Light Source (NGLS). This strategic restructuring of facility upgrades and termination of a proposed facility has been claimed to save between approximately $250 million and $850 million, while simultaneously ensuring the United States remains at the forefront of light source and storage ring science.[43] It also ensures that the broader S&T community will have the facilities it needs.

DOE also collects user community input in less formal ways. Throughout the planning stages for the upgrade to the National Synchrotron Light Source (NSLS) at Brookhaven National Laboratory, DOE, NIH, and the laboratory hosted scientific workshops, working groups and advisory panels. Life sciences research constitutes about 40% of the users of the NSLS and one-third of these users are funded by NIH.[44]

The question is sometimes asked why NSF, NIH, or the National Institute of Standards and Technology (NIST) is not the steward of the large national user facilities. The Commission notes that DOE is by far the largest funder of basic research in physical science in the government.[45] As the above examples illustrate, DOE has developed vehicles whereby the Nation's scientific community has significant input to the strategic planning that is important when dealing with facilities as large as these. In essence, the decision to create user facilities is based on the mission needs of DOE and guided by advice from the scientific community; DOE then constructs and operates them and NSF and NIH funds much of the research that uses the facilities. The Commission notes that the DOE user facilities support important areas of science and they are generally governed in a manner that insures the most competitive proposals are able to use the facilities so that science is advanced in an optimal way. It is therefore the Commission's view that DOE understands the market for these facilities and is the appropriate department to construct and manage them.

b. Research and Development Activities

The processes for R&D activities and those for large user facilities are not entirely distinct. For example, the P-5 report involved both planning and prioritization exercises for user facilities and strategic direction for R&D activities. Since large user facilities

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[43] P. Dehmer, *FY2015 Budget Request to Congress for DOE's Office of Science* (Washington, DC: DOE, 2014).

[44] V. Peña, S. Howieson, and S. Shipp, *Federal Partnerships for Facilities, Infrastructure, and Large Instrumentation* (Washington, DC: IDA Science and Technology Policy Institute, 2013).

[45] NSF, National Center for Science and Engineering Statistics. *Science and Engineering Indicators 2014* (Arlington, VA: NSF, 2014), See Figure 4-20 and Appendix Table 4-37.

affect the direction of R&D activities across many programs, the processes must often be intertwined.

As an example of a new process for coordinating R&D across the laboratory complex, Secretary Moniz organized a Big Ideas Summit in March 2014 with the National Laboratories. The laboratories brought eight topics for consideration to become large DOE initiatives. For three of these ideas, grid modification, subsurface science, and the nexus of energy and water, DOE created Tech Teams to explore the creation of initiatives across the laboratory complex.[46]

Grid modification and modernization is now a top-down initiative from DOE and is becoming well-coordinated across the laboratory complex. Originally, many of the laboratories performed research related to the electric grid. After some success with this research, DOE saw grid modernization as an important program to fund, and now the laboratories have worked with DOE management to create a multi-laboratory grid consortium co-led by NREL and Pacific Northwest.[47] The grid modernization laboratory consortium employs 10 of the laboratories to work on solutions to grid modernization, and to leverage the capabilities at each of the laboratories. This consortium approach is intended to demonstrate that organized laboratory collaboration can be implemented by DOE in addressing grand challenges. One question the Commission will investigate in Phase 2 of its work concerns the timing of the move from numerous independent research projects to a well-coordinated, multi-laboratory effort. The Commission believes that, while important, the coordination of grid modernization research came later than it should have.

Other DOE research areas are not as well coordinated across the laboratory complex. The Commission heard of examples where the money spent through LDRD and WFO was even greater than that funded through the core programs. This, in of itself, is not necessarily an issue, but presents a problem if the programs and laboratories have not coordinated their related research to be sure it achieves the greatest possible benefit. The Commission plans to further explore these areas with the potential for advantageous coordination in the second phase of its efforts.

Another manifestation of the lack of coordination across the laboratory complex is seen in the Department's difficulty in sunsetting older programs. One possible example

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[46] DOE created Tech Teams in advanced computing, clean energy, manufacturing, supercritical carbon dioxide, subsurface technology and engineering, water energy, and grid modernization. See Basic Energy Sciences Advisory Committee to the U.S. Department of Energy, *Public Meeting Minutes July 29-30, 2014*, North Bethesda, MD, 11.

[47] The laboratories involved in the consortium are Ames, Brookhaven, Idaho, Los Alamos, Lawrence Berkeley, Lawrence Livermore, NREL, Oak Ridge, Princeton Plasma, and Sandia. More about the funding and coordination can be found at: http://energy.gov/sites/prod/files/2014/10/f18/07Keynote-PHoffman-WParks.pdf.

that will be investigated further by the Commission in Phase 2 is DOE's biofuels research effort.

c. Appearance of Duplication

An observation of the Commission is that the laboratories have scientific and technical facilities and capabilities that may appear duplicative at a high level but in fact are complementary. Three illustrative examples are highlighted below.

1) Synchrotron Light Sources

DOE has five synchrotron light sources: the Advanced Light Source (ALS) at Lawrence Berkeley; the Advanced Photon Source (APS) at Argonne; the Linac Coherent Light Source (LCLS), which is currently undergoing an upgrade to LCLS-II, at SLAC; the NSLS-II, which is an update from its original NSLS, at Brookhaven; and the Stanford Synchrotron Radiation Light Source also at SLAC (Figure 2).[48] As a whole, the light sources serve over 10,000 users across the fields of biology (including medicine and environmental science), chemistry (including pharmacology), geology, materials science, and physics.

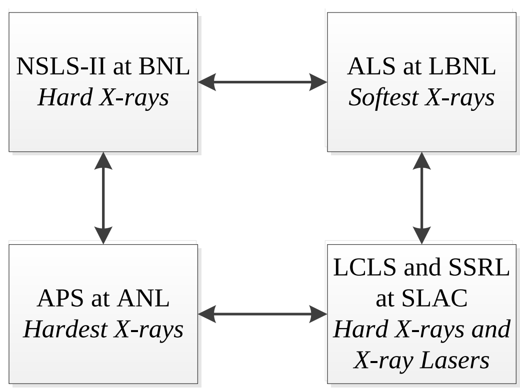

Figure 2. Properties of the Light Beams at Each of the Synchrotrons

Although all the light sources produce intense beams of light, each facility is unique in terms of its spectral output (see Figure 2). The wavelength of the light determines the nature of the research for which the light source is best suited. For example, hard X-rays (short wavelengths) can study the structure of materials on the length scale of an atom, whereas soft X-rays and vacuum ultraviolet light (longer wavelengths) are best suited to study chemical reactions and biological materials. Synchrotrons are used in many fields

[48] More information about the DOE light sources can be found at: http://science.energy.gov/bes/suf/user-facilities/x-ray-light-sources/.

and produce relatively similar science, but the user communities working at the different light sources are notably different.

Another important issue in this connection involves access to these light sources. Within the scientific community, it is generally agreed that regional access to user facilities is critical. Illustrating this point are the concerns voiced by the biology community prior to the upgrades of the NSLS:

> Much of the growth in beamline number, quality and capability in recent years has occurred…in the mid-west and the Bay area. While these developments are welcomed by all because of their positive impact on the nation's scientific capabilities, they pose a significant logistical problem for investigators based on the east coast, who increasingly find themselves having to travel long distances to collect data hands-on at state-of-the-art beamlines.[49]

2) Nanoscale Science Research Centers

Through the National Nanotechnology Initiative (NNI), DOE has five Nanoscale Science Research Centers (NSRCs): the Center for Functional Nanomaterials (CFN) at Brookhaven, the Center for Integrated Nanotechnologies (CINT) at Sandia and Los Alamos, the Center for Nanophase Materials Science (CNMS) at Oak Ridge National Laboratory, the Center for Nanoscale Materials (CNM) at Argonne, and the Molecular Foundry at Lawrence Berkeley.[50] Smaller and more focused nanotechnology research centers exist through other Federal agencies as well, including the National Cancer Institute, NIST, and NSF, which has fourteen facilities located at universities across the country.

The locations of the NSRCs were strategically chosen through peer-review competition by the Office of Basic Energy Science in SC based on the capabilities of the National Laboratories that house them, and their differentiating characteristics parallel the differences in research at the laboratories (see Table 4). The DOE NSRCs also leverage the capabilities of their co-located user facilities. For example, the CNM at Argonne has a dedicated beamline on the APS that uses hard X-ray nanoprobes. Similarly, the Molecular Foundry at Lawrence Berkeley works with both the ALS and the National Energy Research Scientific Computing Center (NERSC).

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[49] BioSync, Biological Applications of Synchrotron Radiation: An Evaluation of the State of the Field in 2002 (Stanford, CA: Structural Biology Synchotron users Organization, 2002), 10.

[50] More information about the DOE NSRCs can be found at: http://science.energy.gov/bes/suf/user-facilities/nanoscale-science-research-centers/ or https://nsrcportal.sandia.gov/Home/About.

Table 4. Detailed Description of Capabilities of the DOE Nanoscale Research Centers

	CFN	CINT	CNMS	CNM	Molecular Foundry
Create	Block Co-polymer Self-Assembly	Giant Nanocrystal Quantum Dots	Stable-isotope labeled soft matter	Hybrid Nanomaterials	Bio and biomimetic nanostructures
	DNA-Mediated Self-Assembly of Nanomaterials	Semiconductor Nanowires	Carbon nanostructures	Oxide Molecular Beam Epitaxy	Robotic synthesis of colloidal nanocrystals
	Electrophoretic Deposition of Nanomaterials	Biomimetic Membranes	Chemistry in confinement	Nanocarbon Materials	Hybrid organic/inorganic mesoscale materials
		Metamaterials	Direct-write EBID nanostructures	Bio inspired hybrid materials	Nanostructured porous frameworks
		High-Mobility MBE	Anionic polymer synthesis	Nanomechanical devices and novel nanofabrication techniques	Sub 10 nm nanofabrication
			Complex oxide heterostructures (PLD)	Engineered nanoparticles	Photonic and mechanical nano-probe
Characterize	In-Operando Nanocatalyst Characterization by Electron Microscopy and Synchrotron Light-Based Spectroscopy	Discovery Platforms	Band Excitation scanning probe microscopy	Hard X-ray nanoprobe: nano-diffraction, fluorescence, and 3D nanotomography	High resolution electron scattering
	Aberration-Corrected Environmental Transmission Electron Microscopy	Nanomechanics	STEM Imaging and Spectroscopy	Ultra high vacuum STM	In-situ probing and imaging
	Ambient-Pressure X-ray Photoemission Spectroscopy	Super-resolution Optical Imaging	Atom probe and electron tomographies	In Situ and Scanning Probe Microscopies	Imaging of magnetic surfaces
	Aberration-Corrected Photoemission Electron Microscopy	Ultrafast Spectroscopy/Carrier Dynamics	He-ion microscopy	Non-linear phenomena	Hyperspectral Nano-optical dynamic Imaging
	Ultrafast Optical Spectroscopy in Electrochemical Environments	Optical Nanoprobes	Operando Electron Microscopy	Time-resolved UV-VIS-NIR-IR emission and absorption spectroscopy	Tomography of single proteins and nanoparticles
	Reactor Scanning Tunneling Microscopy	In Situ Microscopies			Ultrasensitive Liquid AFM
Understand	Bridging from Atomic-scale Theory to Nanoscale Phenomena	Classical DFT at Interfaces	Computational electronic structure theory	Electrodynamics, quantum dynamics of light-matter interactions	Interfacial Electronic Structure/Dynamics
	Theory of Directed Assembly in Soft and BioNanomaterials	Non-adiabatic DFT	Large-scale ab-initio molecular dynamics	DFT, molecular dynamics of molecular conversion and ionic transport	Ab initio Excited-States/Spectroscopy/Transport
		Soft Material Molecular Dynamics	Computational quantum many-body theory	Atomistic simulations of friction and other physical properties of nanoscale materials	Statistical Mechanics of Self-Assembly
			Stochastic interactions in confinement		

Source: Adapted from DOE Nanoscale Research Centers, https://nsrcportal.sandia.gov/Home/Capabilities.

3) High Performance Computing

The National Laboratories have had a significant impact on high performance computing (HPC) in two ways—by conducting the up-front research necessary to field first-of-a-kind systems (e.g., developing code optimized for new computing architectures) and through their procurement, via R&D partnerships with vendors, of several generations of high performance computers. By enabling industry, the DOE laboratories have helped make these machines available to a broad community. Recently, this has resulted in the development of the Cray and IBM BlueGene lines of supercomputers, both of which underwent a long period of co-development at the laboratories before being introduced to a broader, commercial audience. The laboratory's role as key sponsors and customers of supercomputers also drives the technology and the industry in important ways. For example, the laboratories played an important role in establishing floating-point arithmetic (rather than logical operations) as the key performance metric defining high performance computing. This role for the National Laboratories continues as HPC moves into exascale computing.

The DOE laboratory complex boasts 32 of the world's 500 fastest supercomputers.[51] Leading in computing, however, is not just dependent on hardware, and most of the laboratories have a HPC capability with scientists and engineers who utilize the computing power for applications in energy, science, and national security. Differences in these HPC facilities and programs lie in the technical specifications of the machines, and the applications of the research projects. Like the NSRCs, computing centers support their co-located facilities. The SC Advanced Scientific Computing Research (ASCR) Program funds and manages three supercomputing facilities and advanced scientific networks located at Oak Ridge, Argonne, and Lawrence Berkeley.

In addition to purview, the machines and computing centers across the laboratory complex differ on the basis of architecture and computing codes. Highlighting these differences is the newly developed Collaboration of Oak Ridge, Argonne, and Lawrence Livermore National Laboratories (CORAL), which is a procurement and collaboration project between the three laboratories. Oak Ridge, Argonne, and Lawrence Livermore plan an extensive collaboration in the HPC space, leveraging each laboratory's distinctive capabilities and mission. The plan includes new procurements at each laboratory and will be supported by the ASCR Oak Ridge Leadership Computing Facility (OLCF), the ASCR Argonne Leadership Computing Facility, and the NNSA Advanced Simulation Computing (ASC) program. According to the public release, Oak Ridge's new system, Summit, and Argonne's new system will "have architecturally diverse computers to manage risk during a period of rapid technological evolution." [52]

Generally, differentiated HPC programs benefit mission-driven science at the laboratories.[53] In the case of national security, the NNSA Stockpile Stewardship Program

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[51] B. Dotson, "Supercomputers: Extreme Computing at the National Labs." Last modified September 4, 2013.

[52] "Collaboration of Oak Ridge, Argonne, and Livermore (CORAL)." DOE Office of Science and National Nuclear Security Administration. Last modified December 17, 2014.

[53] See SEAB, *Report of the Task Force on Next Generation High Performance Computing* (Washington, DC: DOE, 2014) .

depends on the computing capability of the NNSA laboratories to "assess the safety, security, and effectiveness of the stockpile" in the absence of testing.[54]

E. Summary Observations and Preliminary Recommendations

Based on its work to date, the Commission observes the following:

- In general, the research programs and capabilities at the National Laboratories are well-aligned with DOE's mission and strategic priorities. In Phase 2, additional data on this issue will be gathered.
- Strategic planning for both the Department and its laboratories is best accomplished jointly between DOE and laboratory leadership. Currently, the level of laboratory involvement in DOE strategic planning varies by office.
- The current Secretary and his management team are making advances towards more fully involving laboratory leadership in Departmental strategic planning. It is important to institutionalize these improvements so the Department and laboratories may continue to benefit from these practices in the future.
- To the extent appropriate, the processes that SC has in place for both planning and assessing the quality of the research being done by the 10 laboratories under its stewardship, and for assessing the quality of the research portfolio in each of its programs, should be adopted by the other DOE program offices.
- Duplication in user facilities and R&D programs is intentional, managed and beneficial to the nation. Considering the maturity of the research program area:
    - At very early stages, it is beneficial to have many labs, universities, and other institutions exploring potential avenues for research.
    - In the intermediate stages, DOE may wait too long to provide strategic guidance to the National Laboratories. As a result, there is some period in time in which the laboratories are competing with one another to lay claim to new research areas in a manner that is not strategic.
    - At late stages, in "mature" R&D programs, it is appropriate to have expert peer review teams from universities, industry and other relevant communities guiding DOE on where there should be centers of excellence, how much duplication to support, etc.

[54] "NNSA Stockpile Stewardship Program Quarterly Experiments," *National Nuclear Security Administration*, Accessed January 15, 2015, http://nnsa.energy.gov/ourmission/managingthestockpile/sspquarterly.

- The Commission finds that there is still a “broken trust” between the laboratories and the Department; the degree of micromanagement and transactional oversight that continues at DOE (both headquarters and site offices) is not appropriate under the FFRDC model described in Chapter 2. The current Secretary is making great strides in improving this, and those changes should be recognized and institutionalized to the extent possible.

5. Engagement with and Support to the Broader S&T Community

Whether by the diffusion of novel technologies, stewardship of user facilities, or partnerships with commercial businesses large and small, the laboratories contribute to the broader scientific and national community in integral and irreplaceable ways. While the congressional charge specifically mentioned laboratory work supporting other agencies, the Commission felt it was important to also highlight user facilities, collaborations with academia, and industry partnerships and technology transfer. Because the Commission is still in the preliminary stages of data collection and analysis for these latter topics, there are fewer observations and recommendations concerning these areas in this interim report.

A. Mechanisms for Laboratory Collaboration with Other Entities

Part of the Commission's mandate is to assess whether the DOE laboratories "are appropriately supporting other Federal agencies and the extent to which it benefits DOE missions." The Commission has chosen to broaden this assessment beyond Federal agencies to the laboratories' collaboration with academia and industry (including technology transfer), and the important role of user facilities in these collaborations. This broader assessment will continue in Phase 2 and is expected to result in additional findings in the Commission's final report. The nature of this collaboration can vary, to include: research partnerships; publication of joint research papers; contracts for specific projects; the use of DOE facilities, such as its user facilities or work in one of DOE's four Innovation Hubs;[55] Cooperative Research and Development Agreements (CRADAs); personnel exchange programs; and entrepreneurial leave, where a laboratory employee takes a period of time away from the laboratory to develop a product for use in the commercial sector. The great diversity of this work underscores that the national laboratories are truly national assets, serving the broader S&T community, not just supporting DOE missions.

[55] The first hub, the Consortium for Advanced Simulation of light Water Reactors, was established in 2010; the three other hubs are: the Joint Center for Artificial Photosynthesis; the Joint Center for Energy Storage Research; and the Critical Materials Institute.

Many of these collaborations fall under what is commonly referred to as "Work for Others" (WFO);[56] this chapter therefore begins with a review of WFO's purposes and the conditions that must be met to be able to conduct it. DOE defines WFO as "the performance of work for non-DOE entities by DOE contractor personnel and/or utilization of DOE facilities that is not directly funded by DOE appropriations."[57] Such work can emanate from the requirements of other Federal agencies, state or local governments, academia, and industry.[58] This work is further shaped by a number of Federal regulations and internal DOE orders.[59] As outlined in DOE Order 481.1C, and consistent with 48 CFR 970-1707, the purposes of WFO are to:

- Provide non-DOE entities access to highly specialized DOE facilities, services, or technical expertise (to include working in classified environments);
- Assist other Federal and non-Federal agencies in accomplishing otherwise unattainable goals and avoiding possible duplication of efforts;

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[56] WFO has been known by other names as well. In recent years, it has been called Interagency Work and in December 2014, it was renamed Strategic Partnership Projects. However, since WFO is currently the most commonly accepted term, it is what this report uses.

[57] DOE Order 481.1, "Work for Others (Non-Department of Energy Funded Work)."

[58] Section B of this chapter focuses on the Commission's specific mandate: WFO for other Federal agencies. Sections C, D and E offer examples of other types of WFO: academic collaboration, industry partnerships and technology transfer, and user facilities.

[59] Federal regulations include (1) The Atomic Energy Act of 1954 (P.L. 83-303), as amended (42 U.S. Code §2011 et seq.), sections 31, 32, and 33, which authorizes, as appropriate, R&D and certain training activities for non-DOE/non-NNSA entities, provided that private facilities or laboratories are inadequate for that purpose. It enables DOE to direct the development, use, and control of atomic energy towards the generation of public welfare, in addition to its contribution to common defense and security, and (2) The Economy Act of 1932, as amended (31 U.S. Code § 1535), which authorizes Federal agencies to order goods or services from other Federal agencies, and stipulates the conditions for doing so. In turn, DOE Order 481.1C, "Work for Others (Non-Department of Energy Work)," dated 25 January 2005, outlines the objectives and applicable DOE/NNSA requirements that must be satisfied before taking on WFO (consistent with 48 C.F.R. § 970.1707). The DOE Manual 481.1-1A, "Reimbursable Work for Non-Federal Sponsors Process Manual," dated 28 September 2001 and DOE Guide 481.1-1, "Work for Others Guide" describe WFO authorization processes, outline a standard WFO Agreement for non-Federal work, and offer other additional guidance to the facilities on the WFO process.

There are also other documents, which pertain to specific agency(ies), such as: Energy Reorganization Act of 1974 (P.L. 93-438), Section 205 (42 U.S. Code § 5845) requires Federal agencies to furnish to the NRC, on a reimbursable basis, such research services as the NRC deems necessary and requests for the performance of its function. The Homeland Security Act (P.L. 107-296), 6 U.S. Code § 189, specifies the use of DOE laboratories and sites in support of homeland security activities. Work for DHS is to be reimbursed by DHS, but without the (3%) administrative charges imposed on WFO, and the fee DHS pays for LDRD is to fund work that supports DHS missions. DOE is to coordinate its RDT&E activities with DHS to minimize duplication. Executive Order 12333, United States Intelligence Activities, which stipulates that DOE is to participate in collecting and analyzing information on foreign energy matters and to provide expert technical, analytical and research capability to other agencies within the Intelligence Community. And, 10 U.S. Code §188, Interagency Council on the Strategic Capability of the National Laboratories, which lays out the Mission Executive Council's membership and responsibilities; this is addressed in more detail later in this chapter.

- Maintain core competencies at the laboratories;
- Enhance science and technology capabilities;
- Increase R&D interactions between the laboratories and industry, in the interests of technology transfer, development, and commercialization; and
- Retain and attract high-quality personnel. (WFO can appear to be more "relevant" to real-world issues, especially for those at NNSA laboratories.)

WFO offers opportunities for the cross-pollination of ideas among the scientific and engineering communities; helps to ensure greater use of existing facilities; enables some Federal agencies to perform work they would not otherwise be able to do since they do not possess the capabilities and assets themselves;[60] and can sustain S&T capabilities that the DOE budget may not be able to fully support in a given year, but are important to maintain for the long term. As budgets are expected to continue to decline in the out-years, the relative weight of WFO may well increase. At the same time, WFO has sometimes created competing demands for the use of space, facilities, and personnel. This competition has been exacerbated when large amounts of end-of-year funding are sent to the laboratories. Importantly, for WFO to be executed, the work must:

- Comply with the Economy Act (i.e., no direct competition with the domestic private sector),
- Be consistent with or complementary to DOE missions and those of the given facility where the work is to be performed
- Be fully reimbursed by the customer (i.e., full cost recovery),
- Not adversely affect programs assigned to the facility, and
- Not create a detrimental future burden (requirement) on DOE resources.[61]

These are criteria that the DOE site offices must verify are met before a particular WFO project will be approved.

B. Diverse Support of Other Federal Agencies

This section describes the scope of WFO by various Federal agencies and within the laboratories. It then assesses how well Federal agency WFO aligns not only with DOE

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[60] For example, NIH has indicated that it would not have the funds or ability to build a synchrotron light source.

[61] Department of Energy (DOE). "Work for Others Program: Interagency Work." Presentation for the Commission to Review the Effectiveness of the National Energy Laboratories, Alexandria, VA, October 6, 2014. As noted earlier in this report, DHS is specifically chartered to use the National Laboratories to meet its mission requirements; thus, work for DHS is to be performed on an equal basis to work being performed for DOE; it is not required to meet the "non-interference" stipulation.

missions, but also what unique capabilities the National laboratories offer to these other Federal users. It next focuses on the range of customer views about the laboratories' performance—essentially, their level of satisfaction. In looking at the ability of WFO customers to shape the laboratories' capabilities to meet their future requirements, this section concludes with a review of the mandate and performance of the Mission Executive Council (MEC) to date.

1. Varied Scope of WFO

Of the total $17.2 billion funding for the laboratories in FY 2013, WFO accounted for 14% ($2.43 billion). Of that amount, by far the largest customer is the Department of Defense (DOD), accounting for $1.49 billion (61%).[62] The other major Federal agencies supplying funding are: the Intelligence Community (IC); Department of Homeland Security (DHS); Department of Health and Human Services (DHHS), specifically in the form of grants from the National Institutes of Health; NASA, and Nuclear Regulatory Commission (NRC).[63] Other Federal Agencies, representing a lower level of funding, include: Department of State, Federal Bureau of Investigation (FBI), and National Oceanic and Atmospheric Administration (NOAA). Figure 3 depicts these funding levels for FY 2013, as executed (to include non-Federal funding sources as well). A review of total WFO funding since FY 2009 shows little variation year to year, and fairly steady levels of funding from DOD, DHHS, and NASA throughout this time. In contrast, funding from DHS and NRC has fallen by 37% (from $472 million to $278 million) and 34% (from $80 million to $53 million), respectively; according to discussions with the Commission and staff, these declines have generally not been as a result of dissatisfaction with the laboratories' performance, but rather due to overall budget reductions. The concern is that continued budget cuts coupled with continued increased costs for work at the laboratories may well result in the inability of these agencies to have the necessary work done for their missions.[64] In turn, other Federal funding has increased by 36% and non-Federal funding by 20% in that timeframe. Of note, the level of funding from the IC has increased appreciably since 2001.

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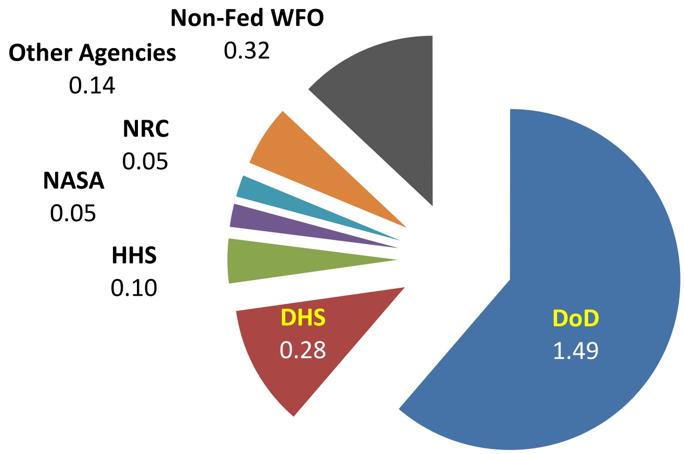
[62] This figure does not include funding for the existing nuclear weapons and naval reactors programs.

[63] For purposes of this unclassified report, the extent of the IC's use of the national laboratories is necessarily discussed in generic terms. The Office of the Director of National Intelligence (ODNI) was established to manage intelligence efforts across a number of Federal organizations (see http:www.intelligence.gov/mission/member-agencies, accessed 8 January 2015). As such, IC inputs to the Commission were coordinated through the ODNI, although individual not-for-attribution interviews were also conducted with IC representatives from several organizations.

[64] As noted in DHS, "Utilization of the DOE National Laboratory Complex: The DHS Perspective." Presentation for the Commission to Review the Effectiveness of the National Energy Laboratories, Alexandria, VA, October 6, 2014, and in not-for-attribution interviews conducted by staff supporting the Commission, November 21, 2014 and January 14, 2015.



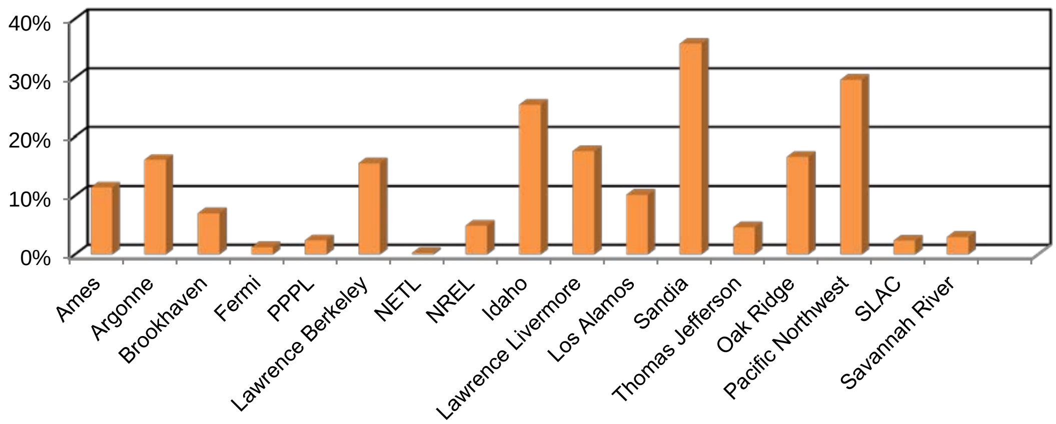
Total WFO: $2.43 billion

Source: DOE Office of Science, "Work for Others Program: Interagency Work," Presentation to the Commission, October 2014.

Figure 3. Actual FY 2013 WFO Funding, by Customer ($ in Billions)

Just as there are appreciable differences across Federal sponsors of WFO at the laboratories, so too are there considerable differences both in the dollar value of WFO and the percentage WFO represents of each laboratory's overall budget. Figure 4 provides data on the latter point in aggregate for FY 2009–FY 2013, as executed.[65] In both categories, Sandia stands apart in terms of WFO's significant role: some $900 million in WFO in FY 2013 accounted for about 35% of Sandia's overall budget.

[65] There have not been large variations in the amount of WFO funding each lab has received over these five years, with two exceptions. One was a dramatic increase in Fermi's funding in FY 2013 due to the state of Illinois funding a building; the second was a marked increase, especially in FY 2012 and FY 2013 at NREL, which was primarily driven by greater DOD investments in energy efficiency work.



Source: Data provided by DOE to the Commission, October 2014.

Figure 4. WFO as a Percentage of Average Total Budgets, FY 2009–FY 2013, by Laboratory

2. WFO Support to DOE Missions and Other Agencies' Needs

DOE has processes in place to ensure that WFO aligns with the Department's missions. The laboratories falling under the Office of Science, for example, are required to prepare a section in their annual report (to the Office of Science) describing the current WFO portfolio, near-term issues, and overall WFO strategy. NNSA laboratories must identify any capability or facility for which external funding is more than 25%.[66] DOE reports that WFO has historically been synergistic with DOE core mission work, and that it has "frequently resulted in cost avoidance at DOE, improved capability for core mission work, and/or workforce development."[67] Multiple Federal agencies identified a range of core DOE mission areas and capabilities that are also part of their mission sets, which the National Laboratories help them address through WFO; these include: modeling and simulation; non-proliferation and weapons of mass destruction threat reduction; physical protection of nuclear materials and facilities; nuclear forensics; knowledge about foreign S&T capabilities; energy efficiency; and wide area surveillance technologies.

Another important dimension of WFO is the extent to which the National Laboratories are able to provide unique capabilities and facilities to these customers. Some of these capabilities—such as genome sequencing at Los Alamos and bio-risk management at Sandia—are widely recognized as being world-class capabilities. Customers also identified the incalculable benefits of being able to use the laboratories' highly qualified personnel for technical advice and as unbiased third-party evaluators. In

[66] Written document prepared by DOE, "Work for Others Program: Interagency Work," 3.

[67] Ibid, 2.

addition, the NRC relies on the unique expertise at laboratories in dose assessments and reactor risk and reliability assessments and analysis. For its part, NASA relies on four of the laboratories for its radioisotope power systems, which currently represents most of NASA support to the DOE laboratories; these laboratories are the only ones that have this capability. Emerging areas of study include nuclear surface power and nuclear thermal propulsion, which NASA anticipates will grow in importance in the coming years. Other unique assets used by other Federal agencies include: the National Ignition Facility (NIF) and Z-division (which provides technical assessments of foreign nuclear programs and weapons capabilities), both at Lawrence Livermore, as well as the synchrotron light sources at Argonne, Brookhaven, Lawrence Berkeley, and SLAC.

3. Federal Agency Satisfaction with the Laboratories' Performance

With few exceptions, those interviewed for this study and those who testified before the Commission noted an overall good-to-high level of satisfaction with the work the laboratories do for them, based on their responsiveness and the overall quality of their work. Many interviewees have noted that the cost of doing business with the laboratories is seen to be high relative to other entities due to their overhead rates (as well as the 3% tax that is levied on all WFO to cover administrative costs associated with managing the work).[68] These high costs can be a deterrent in using them, and may well become a greater factor if Federal agency budgets are further trimmed. While most WFO customers feel they are getting their money's worth, and they recognize that there are expensive facilities and assets at the laboratories that must be maintained, some argue that they are not relying on the laboratories for these facilities, but rather the subject matter expertise, and therefore the rates are excessively high for the type of work being performed. An additional qualifier evident across the interviews is that some laboratories are seen to perform better than others; as one interviewee put it, there are "islands of excellence" but also "pockets of mediocrity."[69] As a result, individual responses in any given organization can run the gamut, and can depend on individual personalities, but the overall consensus is that the laboratories produce high-quality work. Indeed, a number of people from various agencies underscored the important point that WFO customers have the ability to "vote with their purse." The fact that WFO funding has remained steady thereby demonstrates the general level of satisfaction. Finally, there is across-the-board recognition that effective communications and interactions, both with the laboratories and with DOE headquarters, are vital to ensure an understanding of WFO needs now and in the future. Initiatives such as personnel exchanges and having a designated laboratory

[68] At the same time, it is important to note that WFO does not pay for major equipment or facilities. As such, DOE is not recovering all its costs, even though the overhead rates are high. The Commission will explore the issue of overhead rates in much greater detail in its Phase 2 work.

[69] Interview with DOD official, October 21, 2014.

employee frequently visit major customers (serving as a “customer relationship manger”) can help provide these necessary communication channels.

Where satisfaction is much lower is in the role that DOE headquarters plays in WFO. Customers across the Federal agencies make a point of distinguishing between the laboratories who “know what they’re doing, and they do it well,” and DOE, which is seen more often as an impediment and a source of frustration. Few have been as vocal about these frustrations as the nuclear weapons sponsors in DOD, who point to frequent schedule delays and cost overruns (often created by burdensome headquarters-imposed requirements), the lack of transparency in how DOE is spending the funds, and a belief that too much work is focused on “science,” to the detriment of the Life Extension Programs. Technically, however, the Life Extension Programs and other work related to the nuclear weapons program is not “Work for Others”, but part of the core mission of the DOE. Another source of frustration with DOE headquarters is the lengthy process required to obtain WFO approvals, especially within the NNSA laboratories, and the fact that this process is usually the same for a small level of effort as it is for a multi-million dollar initiative. There has been some progress in using standardized umbrella agreements, which identify acceptable areas of work, but this has yet to be applied consistently across the complex.[70] An additional improvement has been NNSA’s creation of the position of Director of Interagency Work, one of the aims of which is to shorten the timeline of the WFO approval process.

Aside from the Life Extension Programs, DOD customers are generally satisfied with the overall relationship, and note the important roles the laboratories play in a number of DOD areas of responsibility, such as threat reduction and energy efficiency, an area of growing interest to DOD. In fact, the laboratories’ efforts to transition to being national security laboratories have made them more useful to other agencies, such as DOD. There are, in fact, some initiatives under way to ensure that the ease of sending work to the DOE laboratories has not led DOD customers to rely too heavily on them. In at least one case, such an initiative resulted in the decision to have a specific project performed outside the laboratory complex, but the process took 9 months longer, the cost was ultimately the same, and the DOD office’s confidence in the quality of the product to be delivered is substantially lower.[71] In the cases of DHS and the IC, strategic

[70] This issue and recommendations to improve the process have been identified most recently in two other studies: Congressional Advisory Panel on the Governance of the Nuclear Security Enterprise, *A New Foundation for the Nuclear Enterprise*, and NRC, *Aligning the Governance Structure of the NNSA Laboratories to Meet 21st Century National Security Challenges*.

[71] Interview with DOD official, October 17, 2014.

investments have been made in some cases to ensure that a capability critical to their missions is maintained.[72]

Both DHS and the NRC have instituted performance reviews of the National Laboratories, soliciting inputs from the program managers on the extent to which the laboratories are meeting their agency mission needs and whether they are providing value-added work.[73] Scoring by both agencies across the laboratories averages 3.6–3.9 out of a total possible 4.3 points, meaning they “exceed” or “notably exceed expectations.” While noting a generally high level of satisfaction, DHS identified two areas as challenges, (1) that the laboratories are often not as focused on the turn-around time DHS requires (typically 18–24 months) and (2) that they are not as transition-oriented.[74] As a way of addressing its satisfaction with the laboratories’ performance, NRC, DOD, IC, and FBI customers all noted that if performance is not up to expectations, they will not do future work with that laboratory or specific principal investigator; it is a “vote with the purse” system.

As noted earlier, the IC has expanded its use of the National Laboratories considerably since the events of 9/11.[75] The IC stresses the importance of knowing that capabilities are there to make a difference for a given IC mission, and knowing whether those capabilities are healthy or are at risk. The IC has also developed a way of funding work at the laboratories which aligns well with meeting its needs and is therefore satisfied with the support the National Laboratories provide.[76]

4. Mission Executive Council

The Mission Executive Council (MEC) was established in July 2010 through the signing of the document “Governance Charter for an Interagency Council on the Strategic Capability of DOE National Laboratories as National Security Assets,” by the leaders of

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[72] Among DHS’ long-term investments are the National Infrastructure Simulation and Analysis Center at Sandia and Los Alamos; the Industrial Control Systems Cyber Emergency Response Team (ICS-CERT) at Idaho; the Biodefense Knowledge Center at Lawrence Livermore; the National Visualization and Analytics Center at Pacific Northwest; and the Interagency Modeling and Atmospheric Assessment Center at Lawrence Livermore. As noted in DHS, “Utilization of the DOE National Laboratory Complex: The DHS Perspective.”

[73] The Office of National Laboratories in the Science and Technology Directorate of DHS has done these assessments, *National Laboratory Performance Assessment*, for FY 2011, FY 2012 and FY 2013. The NRC has done so only for FY 2014, *DOE Survey Results*, because it has only just recently consolidated working with the laboratories into one office, the Acquisition Management Division.

[74] DHS, “Utilization of the DOE National Laboratory Complex: The DHS Perspective.”

[75] Description of the IC’s use and satisfaction with the laboratories is based on a coordinated input received from ODNI as well as not-for-attribution interviews with representatives from the Central Intelligence Agency and the Intelligence Advanced Research Projects Activity.

[76] No further detail about this process can be provided in an unclassified report.

DOE, DOD, DHS, and ODNI.[77] The MEC's purpose is to match the laboratories' technical capabilities with technical needs of the other agencies, thereby providing long-term strategic planning for capabilities that are unique to the DOE laboratories, identifying common areas of interest across these agencies, and (ideally) ensuring the capabilities to address these areas are maintained. The MEC is therefore meant to serve as the mechanism for these agencies to interact with the National Laboratories on a strategic level. The MEC does not, however, involve any financial obligation on the part of any of the signatory agencies.

The MEC consists of two members from each of the four signatory agencies at the undersecretary level; in addition, the Chairman of the DOE National Laboratory Director's Council and the DOD Director for the Defense Laboratories Office regularly attend the MEC's quarterly meetings. About 2 years ago, the MEC's processes were improved by the creation of a planning group, comprised of senior staff from the four departments, which meets much more regularly, thereby providing greater continuity and stability. The MEC is required to report annually, focusing on the following issues: assessing the adequacy of national security science, technology, and engineering capabilities at the laboratories in identified cross-cutting areas; identifying science, technology, and engineering capabilities that need interagency attention; and recommending what capabilities should be developed or sustained in order to close identified gaps. The MEC was further tasked in the National Defense Authorization Act (NDAA) FY 2013 to submit a report on how effective it has been, whether the WFO program has been strengthened, and whether it has worked on ways to increase cost sharing.

A recent National Research Council (NRC) report that looked in detail at the MEC and its performance noted the failure to date of the MEC to fulfill its mandate in many respects and emphasized the need for the MEC to play a greater strategic role.[78] This Commission similarly notes that assessments among those it has interviewed about the MEC's utility to date are tepid at best. While the purpose of the MEC—ensuring the preservation of a technology base to meet government-wide, national needs—is laudable, the question has been raised whether the MEC can have the desired effect without more resources. However, this Commission supports the findings of the NRC report, which argues that the MEC should be reinvigorated to fulfill a strategic role by ensuring that the agencies are aware of the skills of the laboratories and that the laboratories are aware of the major challenges confronting the agencies now and in the future. The NRC report

[77] Its membership and responsibilities are described in 10 U.S. Code § 188, Interagency Council on the Strategic Capability of the National Laboratories.

[78] NRC, *Aligning the Governance Structure of the NNSA Laboratories to Meet 21st Century National Security Challenges*.

also found that the MEC does not need additional authorities to serve as the interagency integrator in identifying future S&T needs and that the MEC should work with OMB, Office of Science and Technology Policy (OSTP), and Congress to advocate for necessary investments in laboratory facilities and equipment, as appropriate.

C. User Facilities

DOE user facilities are federally sponsored research facilities available for external use to advance scientific or technical knowledge. The facilities operate under the following conditions:

- "The facility is open to all interested potential users without regard to nationality or institutional affiliation."
- Allocation of facility resources is determined by merit review of the proposed work.
- User fees are not charged for non-proprietary work if the user intends to publish the research results in the open literature. Full cost recovery is required for proprietary work.
- The facility provides resources sufficient for users to conduct work safely and efficiently.
- The facilities support a formal user organization to represent the users and facilitate sharing of information, forming collaborations, and organizing research efforts among users.
- The facility capability does not compete with those from an available private sector entity."[79]

1. Value to the S&T Community and the National Economy

The Commission considers DOE user facilities to be an indispensable resource to DOE, the broader S&T community, and the Nation as a whole. The user facilities benefit the broader S&T community and the Nation through user communities whose research is often funded through other sources, such as NSF, NIH, NASA, DOD, and private industry.[80] The SC light sources alone are utilized by over 30 Fortune 500 companies and hundreds of universities.[81]

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[79] "User Facilities," *DOE Office of Science*, last modified November 24, 2014, http://science.energy.gov/user-facilities/.

[80] In a hearing to the House Subcommittee on Energy and the Environment, Dr. Antonio Lanzirotti, the chair of the National User Facility Organization, described the collective user community at the time to include 45 Fortune 500 companies, over 600 universities, and 45,000 scientists. 7,000 of these users were estimated to be students and postdoctoral researchers. The list of these companies and universities

In addition to the service provided to the entire S&T community, the laboratories use and operate these facilities to conduct research to support the missions of DOE and other Federal agencies and to attract and to retain top talent.[82] The types of user facilities include X-ray synchrotrons, nanotechnology centers, computing facilities, and fusion reactors. Access to user facilities allows a large number of outside researchers, over 30,000 each year, to perform R&D that often could not be done otherwise.[83] In addition to the capabilities of the machines and facilities themselves, the technical expertise of the laboratory scientists and engineers who use and operate the user facilities are at the foundation of the value added to the government, university, and industry scientists who use these assets in their research. During testimony to the Commission, industry representatives attested to the value of the user facilities and the technical expertise that comes along with them.[84]

In the charter for a House subcommittee hearing on user facilities, the light sources were specifically mentioned as having made "numerous breakthroughs and innovations ultimately applied to advances in industrial sectors such as aerospace, medicine, semiconductors, chemicals, and energy."[85] The far-reaching breakthroughs and innovations due to use of the light sources, just one type of user facility, and further testimony in that subcommittee hearing indicate that single examples of research conducted at these user facilities are not sufficient to explore the full impact of the user communities.[86] However, almost all parties at that hearing (representatives from Congress and from user facilities) specifically mentioned that the collection of user

can be found in the hearing proceedings. *Department of Energy User Facilities: Utilizing the Tools of Science to Drive Innovation through Fundamental Research: Hearing before the Subcommittee on Energy and Environment and the Committee on Science, Space, and Technology, United States House of Representatives*. 112th Cong. 21-61 (2012) (statement of Dr. Antonio Lanzirotti).

[81] From SC Deputy Director Patricia Dehmer's testimony to the Commission on September 15, 2014. The SC light sources are the Advanced Light Source at Lawrence Berkeley, the Advanced Photon Source at Argonne, the Linac Coherent Light Source at SLAC, the National Synchrotron Light Source II at Brookhaven, and the Stanford Synchrotron Radiation Lightsource at SLAC.

[82] During site visits, many early career scientists and engineers mentioned that large user facilities were a key factor in applying for and eventually accepting positions at the DOE laboratories.

[83] In SC Deputy Director Patricia Dehmer's testimony to the Commission on September 15, 2014, she referenced 28,000 users at SC user facilities.

[84] From testimony to the Commission on November 4, 2014.

[85] *Department of Energy User Facilities: Utilizing the Tools of Science to Drive Innovation through Fundamental Research: Hearing before the Subcommittee on Energy and Environment and the Committee on Science, Space, and Technology, United States House of Representatives*. 112th Cong. 21-61 (2012).

[86] At its November 2014 meeting at Argonne, the Commission heard from industry representatives whose companies are involved with the user facilities. On the whole, these industry representatives are satisfied with the value they receive from the laboratories and the user facilities. Any issues dealt with operational and efficiency concerns.

facilities housed by the DOE and its laboratories could not be supported by the resources of any other institution or company.

The number of user facilities across the DOE laboratory complex is between 30 and 80 user facilities. The variability in this value is based on the differing designations for a "user facility."[87,88,89,90] SC, DOE, the National User Facility Organization (NUFO), and the laboratories each have slightly different ways to count facilities as "user," and although overlap exists, the lists are not entirely the same. As described by the SC user facility designation process, user facilities generally provide technical expertise, foster user communities for collaboration and information dissemination, and choose users through "merit review of proposed work."[91] These facilities are in high demand, and the Commission was repeatedly told that some user facilities are up to 300% oversubscribed.[92] The primary complaint from current and potential users regarding the user facilities involves the difficulty in securing access due to the overwhelming demand, and the Commission plans to further explore the level of oversubscription of the user facilities in Phase 2.

2. Operation of User Facilities

User facility planning and operating budgets are determined by the laboratory's stewarding office. SC determines the future of its user facilities with the user communities and the laboratories through its strategic review process (described in Chapter 4), and this review process has the capacity to create new and to terminate older

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[87] The majority of the laboratory complex's user facilities are located at SC laboratories, and work proposals are selected through a merit review process to allocate facility resources. A list of the user facilities designated "user" by each laboratory is provided in Appendix F.

[88] "U.S. Department of Energy Office of Science User Facilities, FY 2015," *DOE Office of Science*, last modified October 1, 2014, http://science.energy.gov/~/media/_/pdf/user-facilities/Office_of_Science_User_Facilities_FY_2015.pdf.

[89] Note that on September 30, 2014, the Electron Beam Microcharacterization Centers at Ames, Lawrence Berkeley, and Oak Ridge were merged with their co-located Nanoscale Science Research Centers. Note also that the National Synchrotron Light Source NSLS has ceased operations for the new facility, NSLS-II. "DOE Designated User Facilities," *DOE*, last modified October 21, 2013, http://energy.gov/sites/prod/files/2013/10/f3/USER%20FACILITIES%2021OCTOBER2013.pdf.

[90] "Facilities," *National User Facility Organization*, accessed January 15, 2015, https://www.nufo.org/facilities.aspx.

[91] "User Facilities," *DOE Office of Science*, last modified November 24, 2014, http://science.energy.gov/user-facilities/.

[92] Oversubscription of user facilities is also discussed in *Department of Energy User Facilities: Utilizing the Tools of Science to Drive Innovation through Fundamental Research: Hearing before the Subcommittee on Energy and Environment and the Committee on Science, Space, and Technology, United States House of Representatives*. 112th Cong. 21-61 (2012) (statement of Dr. Persis Drell).

user facilities.[93] SC also allocates about 40% of its funding to the operation of scientific user facilities.[94]

Although most DOE user facilities are located at SC laboratories, the applied energy and NNSA laboratories also operate user facilities. At NREL, EERE funded the building and operation of the Energy Systems Integration Facility (ESIF). ESIF, like SC user facilities, provides the expertise of experienced scientists and engineers as part of the facility, and in its first year, confirmed 40 partnerships with industry and academia. To ensure success, EERE provides ESIF's operating costs, which the Commission commends. In contrast, the FLEXLAB at Lawrence Berkeley has not been afforded this flexibility, which has resulted in increased dependence on external partnerships to run the facility.

The NNSA laboratories also have SC-like user facilities, including the National Ignition Facility (NIF) at Lawrence Livermore. These facilities support the laboratories' programmatic success and allow external researchers to access the facility. The laboratories also have facilities that benefit other Federal agencies, and although this type of facility is not open to the entire scientific community, the laboratories argue that the value to the users is similar to the SC user facilities.

D. Service to the Academic Community

Since their inception, the National Laboratories have been intimately tied to the academic community, and this relationship continues to invigorate both laboratories and universities today. Through collaborations, universities gain access to the expertise and facilities housed at the laboratories, while the laboratories benefit from the constant exposure to new ideas and directions in science and technology. Through shared research, support of national user facilities, and joint staff appointments, the National Laboratories and universities find various ways to work together for the betterment of society.

1. Laboratory/University Researcher Collaborations

All DOE laboratories conduct joint research ventures with academic counterparts, but those laboratories tied directly to a host academic institution—Argonne, Ames, Lawrence Berkeley, Brookhaven, Fermilab, Princeton Plasma Physics, and SLAC—benefit from especially close relations with partnering universities.

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[93] Most recently, the Tevatron Collider at Fermi and the Holifield Radioactive Ion Beam Factory at Oak Ridge were discontinued, and the upgrade of NSLS (NSLS-II) at Brookhaven was confirmed. SC also funds user facilities that are not located within the DOE Laboratory complex including the General Atomics DIII-D Tokamak and the Michigan State University construction and operation of the Facility for Rare Isotope Beams (FRIB).

[94] From testimony to Commission, from interviews, and in House user facility hearing proceedings (112th Cong. 21-61 (2012)).

Other factors affect the level of university-laboratory collaborations. Laboratories with classified missions collaborate less with the academic community, while those located near top-tier research universities benefit from the proximity through both greater visibility and opportunities for joint staff appointments. Having a university M&O contractor also improves collaborative prospects: for instance, Lawrence Livermore benefits from a variety of University of California-affiliated initiatives, such as University of California laboratory and visiting scholars programs. During Phase 2, the Commission will complete an analysis of co-authorship of scientific publications by personnel at the 17 laboratories and expects it will reveal other factors that impact partnerships with the academic community.

2. Multi-institution Funding Constructs

In addition to researcher collaborations, DOE has initiated multi-institution partnerships through initiatives such as the Energy Innovation Hubs, Energy Frontier Research Centers (EFRCs), and the Bioenergy Research Centers (BRCs). Each of the four multi-million dollar Energy Innovation Hubs focuses on a particular energy challenge that had been resistant to solution by conventional R&D management. Three of the four are led by a National Laboratory. The EFRCs are multi-investigator, multidisciplinary centers led by universities, National Laboratories, and private research institutions. The 46 EFRCs launched in August of 2009 involve 850 senior investigators; 2,000 students, post-doctoral fellows, and technical staff; 115 institutions; and over 260 scientific advisory board members from 13 countries and over 40 companies. The three BRCs are vertically integrated research institutes, and two of them are led by National Laboratories.

The ultimate goal of these multi-institutional mechanisms is to combine innovation, risk tolerance, and disciplined project management to identify and support a portfolio of projects that are risky and exploratory and focused on delivering innovative products into real applications.[95] SEAB recently completed a review of these constructs and found that each has been successful in encouraging collaboration of the National Laboratories with academia (in the case of the EFRCs) and with both academia and industry (in the case of the BRCs and Hubs), but it recommended more disciplined management on the part of DOE.[96] One criticism of the Hubs is that the system results in the proposal “losers” being excluded from the project, when they likely could still make valuable contributions to the endeavor.

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95 SEAB, *Task Force Report to Support the Evaluation of New Funding Constructs for Energy R&D in the DOE* (Washington, DC: DOE, 2014).

96 Ibid.

E. Partnering with Industry and Transferring Technology

The National Laboratories partner with industry and transfer technology through many channels. Table 5 describes various ways laboratories transmit their work to society. Laboratory impacts on the market and society can be captured in part through metrics such as patents, invention disclosures, and cooperative research and development agreements (CRADAs). These measures attest to direct transfers of laboratory knowledge, but laboratories also disperse innovative ideas and technologies through the other mechanisms described, some of which produce impacts that are harder to quantify in terms of return on investment but still support the diffusion of important technological ideas. The diversity of mechanisms speaks to the different sorts of collaborations that occur at the National Laboratories.

Table 5. Mechanisms for Technology Transfer

Indirect Pathway Mechanisms	Direct Pathway Mechanisms	Network Pathway Mechanisms
Conference papers	*Invention protection*	Commercialization Assistance Program
Education Partnership Agreements	Invention disclosures	Entrepreneurship-in-residence programs
Field days	Patent applications	Entrepreneurship training
Hiring students	Issued patents	Mentor-protégé program
Publications	*Direct transfer of property*	Personnel Exchange Agreements
Seminars	Material Transfer Agreements	Partnership Intermediary Agreements
Teaching	Patent licenses	Venture capital forums
Workshops	*Collaborative Research Agreements*	
	Cooperative Research and Development Agreements	
	Resource Use Agreements	
	Commercial Test Agreements	
	User Facility Agreements	
	Work for Others	
	Participation in startups by laboratory researchers	

Source: Hughes et al. (2011), adapted from Ruegg (2000) and FLC (2009).

Technology transfer data for FY 1999 to FY 2011 can be found in Table 6.

Table 6. DOE Laboratory Technology Transfer Data

FY	Total Active CRADAs	New CRADAs	Invention Disclosures	Patent Applications	Issued Patents	New Licenses	Total Income from Invention Licenses ($Thousands)
1999	715	240	1474	850	525	202	1,545
2000	687	151	1371	788	515	169	2,835.5
2001	558	204	1527	792	605	226	1,870.1
2002	872	192	1498	711	551	206	21253.3
2003	661	140	1469	866	627	172	23,670
2004	610	157	1617	661	520	168	23,321
2005	644	164	1776	812	467	198	24,226
2006	631	168	1694	726	438	203	32,211
2007	697	182	1575	693	441	164	34,933
2008	711	178	1460	904	370	177	43,108
2009	744	176	1439	775	520	139	40,238
2010	697	176	1616	965	480	166	37,066
2011	720	208	1820	868	460	169	40,600

Source: NIST, Federal Laboratory Technology Transfer Fiscal Year 2011: Summary Report to the President and Congress, September 2013; NIST, Federal Technology Transfer Data 1987–2009, October 2011.

1. DOE and Technology Transfer

Since the 1980s, technology transfer has been a formal responsibility of every laboratory scientist and engineer consistent with their mission responsibilities.[97] However, for decades, DOE has endured political pressure oscillating between criticisms for favoring industry too much and condemnation for not doing enough to boost the economy. For a period in the mid-1990s, Congress provided DOE with funds to support researchers in CRADA participation, which led to a rise in the number of CRADAs at the National Laboratories. An article in *The Philadelphia Inquirer* derided the practice as "corporate welfare."[98] The GAO determined that the elimination of this type of CRADA and other funding programs resulted in a 40% decrease in the number of DOE CRADAs between 1996 and 2001. According to GAO, many industry partners cancelled CRADAs when they learned that they would have to cover all the research costs.[99]

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97 Federal Technology Transfer Act of 1986 (P.L. 99-502), codified at 15 U.S. Code § 3710(a)(2).

98 G. Gaul and S. Stranahan, "How Billions in Taxes Failed to Create Jobs" *Philadelphia Inquirer*. June 4, 1995.

99 General Accounting Office (GAO), *Technology Transfer: Several Factors Have Led to a Decline in Partnerships at DOE's Laboratories* (Washington, DC: GAO, 2002).

The pendulum swung the other way when, about a decade ago, Congress directed DOE to increase its focus on technology transfer through the Energy Policy Act of 2005.[100] The act required DOE to establish a technology transfer coordinator, a technology transfer working group and an energy technology commercialization fund to promote energy technologies for commercial purposes. The fund was intended to be an annual set-aside of 0.9% from applied research and development funds.[101] Up until now, the Department has met the obligation by counting CRADAs and similar technology transfer agreements.[102]

More recently DOE and its laboratories have been the subject of a number of reports criticizing their lack of engagement with industry to bolster national and regional economic development.[103]

Not surprisingly, given this history, DOE has not taken a consistent department-wide stance on technology transfer and partnering with industry. This has led to differences in emphasis on and mechanisms used for technology transfer at the National Laboratories, which is largely dependent on the laboratory's stewarding office. As the lead laboratory for DOE's EERE, NREL stresses transferring applicable energy technologies more heavily than basic research-focused SC laboratories. Individuals within SC have specifically argued that products of DOE basic research laboratories are too far removed from the market to justify funding their advancement through mechanisms such as technology maturation funds. These laboratories have traditionally relied more heavily on dissemination through publications and conferences, rather than industry partnerships.

The Commission recognizes the importance of a positive culture for engaging in technology transfer and partnering with industry. Researchers will be more likely to participate in these activities if they feel leadership at both the laboratory and DOE is supportive of their efforts. The Commission also recognizes that each laboratory is likely to have its own approach to technology transfer and economic development, reflecting the laboratory's unique mission, culture and geographic setting.

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[100] Energy Policy Act of 2005 (P.L. 109-58).

[101] Ibid, Sec. 1001(e) Technology Commercialization Fund.—The Secretary shall establish an Energy Technology Commercialization Fund, using 0.9 percent of the amount made available to the Department for applied energy research, development, demonstration, and commercial application for each fiscal year, to be used to provide matching funds with private partners to promote promising energy technologies for commercial purposes.

[102] T. Michael, "The Mysterious Tech Commercialization Fund." *Innovation* 11, no. 3 (2013).

[103] N. Loris, S. Pool, J. Spencer, M. Stepp, *Turning the Page: Reimagining the National Labs in the 21st Century Innovation Economy* (Washington, DC: The Information Technology and Innovation Foundation, 2013); S. Andes, M. Muro, M. Stepp, *Going Local: Connecting the National Labs to their Regions for Innovation and Growth* (Washington, DC: The Brookings Institution, 2014).

2. Barriers to Industry Partnerships

In 2009, DOE identified numerous barriers to productive laboratory-industry interactions through a request for information (RFI) to industry. According to the responses, indemnification clauses and advanced payment for CRADAs can be significant challenges, especially for small and medium-sized businesses. These requirements shield the government from risk, but limit potential opportunities for collaboration and inhibit technology transfer. Respondents also pointed to heightened DOE U.S. manufacturing requirements.

In addition to legislative and regulatory barriers, interviewees raised a number of other issues. Many reported that working with laboratories was expensive, citing high laboratory overhead rates as the greatest barrier to partnership. Also the timescale for doing experiments at DOE laboratories often does not match industry requirements. Furthermore, non-uniform intellectual property and contractual terms, applications and scheduling processes across the laboratory complex makes partnerships cumbersome for institutions and industry that seek expertise from multiple laboratories. For their part, laboratories argued that technology transfer is to some degree an "unfunded mandate" with unrealistic expectations: laboratories are obliged to produce positive benefits to society, but without dedicated funding from DOE to support technology transfer and industry partnerships.

Finally, many technologies under development at DOE laboratories are at too early a stage to ignite industry interests. Absent technology maturation funds or private sector funding, these technologies stagnate in the development pipeline and never reach the market. This technological "valley of death" is widely recognized, and many past efforts have sought to tackle the issue. This issue is discrete from other barriers identified by interviewees and the 2009 RFI. Even if all other administrative and legal barriers are addressed, technology maturation remains a time and resource-intensive process that requires dedicated investment to succeed.

3. Innovative Practices

Partnerships between laboratories and industry benefit the Nation by transitioning laboratory technologies to broad applications. To facilitate these partnerships, laboratories have developed innovative tools and mechanisms, including physical institutions and legal mechanisms, which make the laboratories more accessible.

At some laboratories, physical institutions support technology transfer and industry partnerships explicitly. For example, at Fermilab, the Illinois Accelerator Research Center interfaces with industry and seeks possible commercial applications for accelerator technologies. Similarly, Lawrence Livermore and Sandia have jointly established the Livermore Valley Open Campus initiative. Launched in 2010, the campus supports industrial collaboration research and development in unclassified areas, allowing

Livermore and Sandia researchers to apply their non-weapons skills and work more easily with industry. In 2011, Livermore also opened its High Performance Computing Innovation Center, which explores innovations in hardware and predictive simulation capabilities for potential industrial applications.

Laboratories also use targeted funding to stimulate the time and resource-intensive process of technology maturation. A 2013 study by the IDA Science and Technology Policy Institute (STPI) identified technology maturation fund programs over the past 20 years at both the laboratory and headquarter level. Among them were the DOE Office of Science Laboratory Technology Research Program (1992–2004) and the more recent EERE Technology Commercialization Fund (2007–2008).[104] Both centralized programs have been discontinued, but laboratories continue to invest in their own technology maturation programs using funds gathered from royalties, DOE funding, and state government support. Program size varies across laboratories, but STPI reported that demand for technology transfer funds exceeded supply in all cases. Dedicated funding to laboratories for technology maturation is not uniformly supported by offices within DOE.

Legal hurdles can often discourage collaborations with industry, leading some laboratories to explore new creative legal mechanisms to increase partnerships. For example, Lawrence Berkeley has created CalCharge, a modified "umbrella" CRADA that allows companies to join in as little as 6 weeks and is especially favorable to small companies that may not have the capital to invest fully in a traditional CRADA. Sixty small California companies are currently involved in CalCharge, and SLAC has also adopted the CalCharge model. In 2011, DOE also began a 3-year pilot program for its Agreements for Commercializing Technology, as a simpler and more nimble alternative to the more contractually complicated CRADAs and WFO.[105] Eight laboratories initially opted to participate in the pilot and the program has been extended.

Laboratories and DOE have also taken some steps to lower the costs of partnerships and facilitate access to laboratories' facilities. To lower costs for small business, America's Next Top Energy Innovator Program works to lower costs of an option agreement for up to three patents and deferring patent costs for startup companies.[106] The five laboratories with Nanoscale Science Research Centers have established a single entry point, simplifying the process and avoiding duplicative applications.

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[104] S. Howieson, E. Sedenberg, B. Sergi, and S. Shipp. *Department of Energy Technology Maturation Programs*. IDA Paper P-5013 (Washington, DC: IDA Science and Technology Policy Institute, 2013).

[105] S. Howieson, B. Sergi, and S. Shipp, *Department of Energy Agreements for Commercializing Technology*. IDA Paper P-5006 (Washington, DC: IDA Science and Technology Institute, 2013).

[106] K. Edmonds, "America's Next Top Innovator: Lab Tech for Startups," *DOE*, last modified March 27, 2013, http://energy.gov/articles/americas-next-top-innovator-lab-tech-startups.

Several laboratories have attempted to encourage their researchers to engage in entrepreneurial activities through entrepreneurial leave programs. For example, Sandia has established the Entrepreneurial Separation to Transfer Technology program. The program allows employees to leave to start a company and guarantees reinstatement if the researcher returns within two years. Researchers can request an extension for a third year. Between 1994 and 2008, nearly 140 Sandia employees participated. Entrepreneurial Separation to Transfer Technology program alumni have started 44 and expanded 46 companies.[107]

F. Summary Observations and Preliminary Recommendations

Based on its work to date, the Commission observes the following:

- The National Laboratories are national assets that perform important work that goes beyond DOE's own programs and supports other Federal agencies, public institutions, universities, and the private sector. The laboratories provide unique capabilities in terms of expert personnel capable of providing both large-scale, long-term support and meeting rapid response needs. They also build and operate large-scale, state of the art research facilities that are used extensively by the broader science and technology community in support of many diverse public and private needs.
- DOE has policies in place to ensure that WFO meets necessary criteria and, in appropriate areas, aligns with the Department's missions. In Phase 2, the Commission will examine these processes and practices in more detail at both DOE and the laboratories.
- On the whole, WFO customers are very satisfied with the quality and value of the work performed by the laboratories. However, many customers feel that laboratory costs are high relative to other institutions. They are also less satisfied with interactions with DOE headquarters.
- Absent established relationships with DOE or the laboratories, it is sometimes unclear to WFO customers where to find the needed capability within the National Laboratory complex. Various forms of communication, to include personnel exchanges and "customer relationship managers" have been tried in some areas and have proven helpful.
- There is insufficient strategic planning involving other Federal agencies regarding their future needs for expert personnel and facilities to support WFO.

[107]"Sandia Entrepreneurial Program Is Back," *Sandia National Laboratories*, last modified November 24, 2008, https://share.sandia.gov/news/resources/releases/2008/entrepreneur.html.

- The Mission Executive Council, consisting of the DOE, DOD, DHS, and the IC, is not as effective a coordination resource as it was intended to be.
- Some Federal agencies have established an annual process to evaluate their level of satisfaction with the DOE laboratories performance, but this is not done systematically across all WFO sponsors nor do the existing evaluations differentiate notably among the laboratories.
- The user facilities at the National Laboratories are a unique and enormously valuable national resource to researchers at other Federal agencies, academic institutions and the private sector here and abroad. For example, researchers funded by NSF and NIH account for as many as half of the users at some key DOE user facilities. All of the user facilities run competitive, peer-reviewed processes to allocate time among potential researchers and many are over-subscribed.
- The strategic planning process regarding user facilities is very strong. The best-run processes, such as those of SC, involve extensive work by peer review panels that utilize experts from the DOE National Laboratories, other Federal agencies, universities and the private sector. These processes aim to develop long-term technical and funding plans for new and existing user facilities that meet national R&D needs and avoid inappropriate duplication. It is not yet clear to the Commission how consistent these processes are across all DOE program offices.
- New funding approaches for collaborative and multi-institution R&D for the National Laboratories, academia and the private sector appear promising. These include the Energy Frontier Research Centers and the Energy Innovation Hubs. The Commission intends to examine these programs more fully, as the results have been mixed.
- Technology transfer and partnering with industry is an important part of the mission of the National Laboratories. While there are hundreds of CRADAs and other forms of collaboration with the private sector throughout the laboratory complex, support for technology transfer is inconsistent across the laboratories and across the DOE program offices.
- The barriers to partnership, especially with small business, are complex and seem to be significant. The financial cost of collaboration with the National Laboratories, including the advance funding requirement, appears to be an important issue. The Commission will continue to examine this and other challenges preventing efficient and effective laboratory-industry partnerships and attempt to identify potential solutions.

- Laboratories have experimented with many innovative mechanisms for engaging industry to make such collaboration easier, faster, more efficient and more effective. These include physical institutions, legal mechanisms, targeted funding and programs to encourage laboratory researchers to engage in technology transfer.

Based on these observations, the Commission makes the following preliminary recommendations with respect to the laboratories' support to the broader S&T community:

- DOE should establish various techniques to make the WFO process more efficient:
  - Institutionalize on-going efforts to streamline the contracting process through more consistent use of umbrella agreements and oversight mechanisms dedicated to shortening the timeline of the approval process.
  - Encourage greater use of personnel exchanges and "customer relationship managers."
  - Create a central point of contact in DOE headquarters to field questions from WFO customers about where specific capabilities lie within the laboratory complex.
- The Secretary of Energy should spearhead efforts to strengthen the MEC by improving its focus on strategic issues. This strategic focus should include efforts already identified in other recent reports:[108]
  - Provide the mechanism for interagency strategic S&T planning, including the development of a mission statement for the laboratories for their "national security mandate."
  - Develop a systemic approach, to include working with OMB, OSTP, and Congress, to advocate for necessary investments in laboratory facilities and equipment.
  - Serve as the vehicle for WFO customers to offer more predictable mission sets for the next several years to help guide the laboratories' investments in staff and facilities.
- The coordinating office for contacts with the laboratories within all major Federal WFO agencies should establish annual evaluation processes, drawing on

[108]Recommendations 2, 3, and 5 in NRC, *Aligning the Governance Structure of the NNSA Laboratories to Meet 21st Century National Security Challenges*, and Recommendation 19 in Congressional Advisory Panel on the Governance of the Nuclear Security Enterprise, *A New Foundation for the Nuclear Security Enterprise*.

the processes already established at DHS and the NRC. For all these agencies, these evaluations should be made more rigorous so that the evaluations better highlight areas of excellence and areas needing improvement.

- DOE and the laboratories should fully embrace the technology transfer mission and continue working to improve the speed and effectiveness of collaborations with the private sector.
- DOE should encourage the laboratories to adopt the innovative mechanisms their fellow laboratories have piloted.
- While uniform practices and procedures would facilitate industry engagement, particularly by small businesses, flexibility should be retained due to the wide variety of contexts found in the laboratories.

6. Laboratory Directed Research and Development (LDRD)

As science advances and the nation's priorities change, the National Laboratories must keep an eye to the future, adapting and updating their skills and capabilities to meet evolving mission needs. The ability to adapt, retool, and invest in staff, capabilities, and enter new research areas is crucial to laboratory performance. Laboratories rely in part on LDRD programs to achieve these goals. LDRD is the sole source of discretionary research funding under the control of the laboratory director for the National Laboratories.

Congress has charged the Commission to analyze the effectiveness of the use of LDRD to meet DOE's science, energy, and national security goals; evaluate departmental oversight of the LDRD program for statutory compliance; and quantify the extent to which LDRD supports recruitment and retention of qualified staff. The Commission is currently in the preliminary stages of its analysis of LDRD, and will further investigate LDRD during the next phase of its study. Preliminary findings are included in this interim report.

A. What Is LDRD?

LDRD is a discretionary program designed to support researcher-initiated work of a creative and strategic nature. By allowing researchers to pursue and explore future directions in research, LDRD serves an important function in maintaining the ability of laboratories to meet the nation's highest energy and national security challenges. Authority to fund and manage discretionary research programs within the laboratories was first authorized in the Atomic Energy Act of 1954, and was organized into an official DOE program in the NDAA FY 1991.

LDRD's five primary objectives as articulated by DOE Order 413.2B[109] are:

- Maintain the scientific and technical vitality of the laboratories;
- Enhance the laboratories' ability to address current and future DOE/NNSA missions;
- Foster creativity and stimulate exploration of forefront science and technology;

[109] Department of Energy, DOE Order 413.2B (January 31, 2011).

- Serve as a proving ground for new concepts in research and development; and
- Support high-risk, potentially high-value research and development.

The LDRD program meets these goals through the competitive solicitation and funding of LDRD projects, awarding projects by merit using a peer-review process similar to processes used by NSF. LDRD projects might serve as proofs of concept in emerging fields, address significant technical challenges facing laboratory programs, or explore innovative concepts to address DOE missions. Many laboratories also depend on LDRD to support the recruitment and retention of qualified staff.

Laboratories acquire funding for LDRD as an overhead fee on all work performed at the laboratory. Authorizing legislation limits total LDRD expenditures to a set percentage of the laboratory's annual operating budget, which has fluctuated over time. The current cap for LDRD is 6% annually, reduced from 8% in FY 2014 under the Consolidated Appropriations Act for FY 2014.[110] Before FY 2006, research projects funded by LDRD were not charged overhead fees, but today's LDRD projects are charged fully burdened overhead rates for researcher time and the use of laboratory facilities.

B. Laboratory Implementation and DOE Oversight

When crafting LDRD programs, laboratory directors balance individual laboratory needs with the strategic interests of DOE and other major customers. Proposed plans for the size of each laboratory's LDRD program are reviewed by their stewarding offices at DOE. Once funding levels are approved, laboratories distribute LDRD funds to researchers competitively, based on merit-based review of project proposals. To ensure the objectivity and quality of review, laboratories use both internal research staff and external reviewers from industry and universities to assess the scientific merit of proposals.

Laboratory directors have discretion to design LDRD proposal solicitations to meet specific laboratory needs, and often emphasize projects that directly relate to major laboratory and Department strategic initiatives. For example, each year Lawrence Berkeley solicits proposals in topical areas consistent with that fiscal year's Lab Strategic Plan. In its recently released FY 2016 Call for Proposals, the laboratory identified four topical initiatives: Exploration of Novel Computing Technologies, ALS-U Science and Technology, Microbes to Biomes, and Energy Innovation.[111] Because LDRD is proposal-

[110] Consolidated Appropriations Act, 2014 (P. L. 113-76).

[111] "Call for Proposals Information FY 2016 Laboratory Directed Research and Development Program," *Lawrence Berkeley National Laboratory*, Accessed December 15, 2014, http://www2.lbl.gov/DIR/LDRD/cfp/information.html.

based, laboratories can also capture innovative ideas of high scientific merit that fall outside of explicit strategic initiatives but still relate more broadly to DOE's missions.

DOE site office and headquarters staff are required to review and approve all projects within the LDRD portfolio for mission alignment and compliance with the Department's statutory requirements.[112] These requirements prohibit the use of LDRD funds for projects that would require non-LDRD funds to accomplish its technical goals, general purpose capital expenditures, and as substitution for programmatic projects where funding has been limited by Congress or DOE/NNSA.

Congress has previously raised concerns over the discretionary nature of the LDRD program, and identified as potential issues the improper use of LDRD funds, mismanagement of the program and lack of mission alignment within the project portfolio.[113] LDRD has been the focus of a number of external studies, though recent reviews and audits of LDRD have made generally favorable judgments of the program. In GAO's most recent study, GAO answered eleven congressional questions related to LDRD and found that the program met statutory requirements and that laboratories clearly communicated the costs of LDRD to customers.[114] More recently, DOE's Inspector General reported in an audit to determine whether LLNL was effectively managing its LDRD program that "nothing came to [the Inspector General's] attention to indicate that controls were not in place over initial LDRD project approval and subsequent project management," and made no recommendations regarding the program's management.[115]

Interviewees at DOE headquarters and laboratories report that the current LDRD program is well-managed to support DOE and other Federal agency missions and that existing oversight mechanisms ensure compliance of LDRD with Department regulation. Oversight is important to ensure that laboratories use LDRD funds appropriately, but the Commission believes that the statutory requirement that every LDRD project be individually reviewed—which in FY 2014 totaled 1,662 projects—may be excessively costly and burdensome to both Departmental and laboratory staff. The Commission suggests periodic audits or a sampling of each year's project pool may be sufficient for compliance and a more efficient alternative to current oversight.

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[112]Appendix G provides further information.

[113]FY 2005 House Report 198-554 and FY 2006 House Report 109-86 raise specific concerns about the accounting policies and management of LDRD. Similarly, GAO released reports in 2001 and 2004 in response to congressional concerns over whether LDRD programs met DOE selection guidelines and statutory requirements, and whether LDRD costs were being clearly communicated to customers.

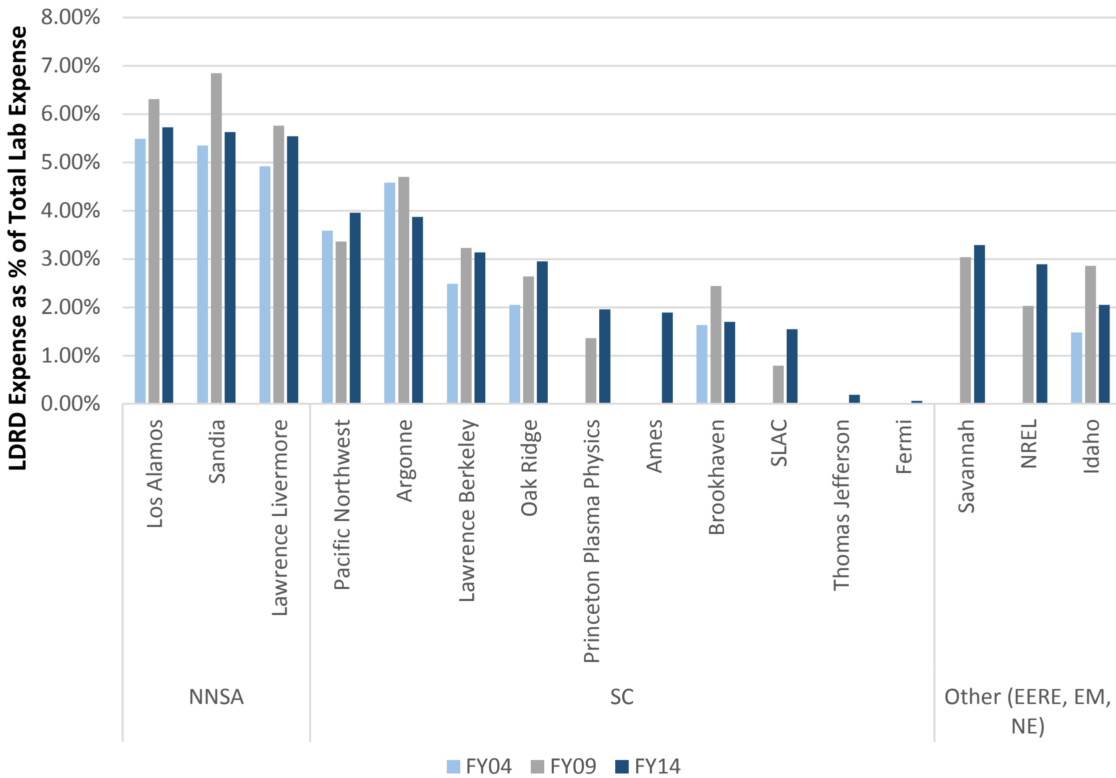
[114]GAO, *Information on DOE's Laboratory-Directed R&D Program* (Washington, DC: GAO, 2004).

[115]DOE Office of Inspector General, *Audit Report: Lawrence Livermore National Laboratory's Laboratory Directed Research and Development Program* (Washington, DC: DOE, 2014).

In the second phase of its study, the Commission will continue reviewing LDRD's management and oversight to ensure that it is both effective and not overly burdensome.

C. LDRD Funding Levels

Funding levels for LDRD vary widely across laboratories, reflecting the diversity of the laboratories in terms of size and mission needs. Figure 5 represents reported LDRD spending as a percentage of total laboratory expenditures in FY 2004, FY 2009, and FY 2014, arranged by stewarding office (NNSA, SC, and other). During FY 2004 and FY 2014, the percentage cap on LDRD spending was 6%, versus 8% from FY 2006 to FY 2013.



Data from DOE Fiscal Year 2004 and Fiscal Year 2014 LDRD Reports to Congress. Laboratories that did not report LDRD data for specific years did not have LDRD programs during those years. As a government-owned, government-operated laboratory, NETL does not have an LDRD program.

Figure 5. Reported LDRD Spending as a Percentage of Total Laboratory Expenditures, FY 2004, FY 2009, and FY 2014

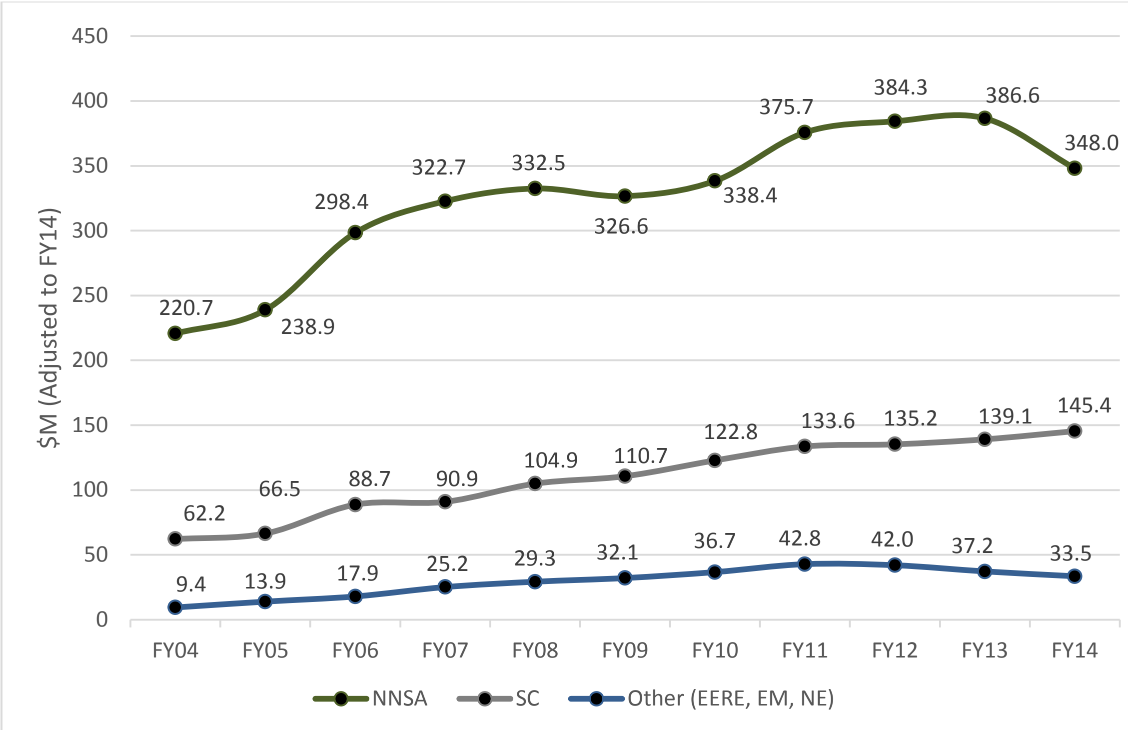
Total spending on LDRD in FY 2014 totaled $526.9 million, represented in descending order by laboratory in Table 7.

Table 7. FY 2014 LDRD Costs by Laboratory

	LDRD Costs ($M)	LDRD Costs (%)
NNSA		
Sandia	151.3	5.63%
Los Alamos	118.5	5.73%
Lawrence Livermore	78.2	5.54%
Office of Science		
Pacific Northwest	38.9	3.96%
Oak Ridge	36.3	2.95%
Argonne	29.2	3.87%
Lawrence Berkeley	23.6	3.00%
Brookhaven	9.6	1.70%
SLAC	4.4	1.55%
Princeton Plasma Physics	2	1.96%
Ames	1	1.89%
Fermilab	0.2	0.06%
Thomas Jefferson	0.2	0.19%
Other (EM, NE, EERE)		
Idaho	17	2.05%
NREL	10.3	2.89%
Savannah	6.2	3.29%
Total LDRD Costs	526.9	n/a

Source: Data from DOE Fiscal Year 2014 LDRD Report to Congress.

NNSA laboratories were responsible for 66% of total LDRD expenditures for FY 2014, compared to 27.6% at Office of Science laboratories and 6.6% at the remaining laboratories. These proportions have remained roughly consistent over time, as represented in Figure 6. Beginning in FY 2006, Congress began requiring that LDRD pay fully burdened overhead rates, which cut the amount of funding available to do technical and scientific work roughly in half. The drop in funding seen in FY 2014 reflects the reduction of the percentage cap on LDRD from 8% to 6%, which primarily impacted the NNSA laboratories.



Source: Data from DOE Fiscal Year 2004-2014 LDRD Reports to Congress.

Figure 6. Total LDRD Spending, FY 2004–FY 2014

NNSA laboratories spend more on LDRD in both percentage and absolute terms. This is a result of both greater total laboratory expenditures and different mission needs. Staff recruitment and retention was cited as one of the major outcomes of LDRD programs at NNSA laboratories. Interviewees reported that defense and nonproliferation programs at the three NNSA laboratories lack extensive opportunities for researchers to pursue investigator-driven, program-independent research. Independent research is important to staff scientists, so NNSA laboratories use LDRD to provide research staff these opportunities. In doing so, laboratories are able to recruit the highest quality researchers in a field where laboratories must compete with academia and industry for talent. LDRD's broader scope also lets laboratory researchers engage with peers in the scientific community, exposing them to new ideas and preventing them from becoming isolated from progress in their fields. While this may give the impression that LDRD programs are not sufficiently mission-focused, broadened scope ensures laboratories can effectively develop their workforce and anticipate needs for future national security challenges. NNSA oversight still ensures that projects remain pertinent to the broader DOE mission.

Non-NNSA laboratories elect lower LDRD rates for a variety of reasons. Interviewees reported that science and energy laboratories rely less heavily on LDRD to recruit and retain staff due to the research opportunities already available through programmatic work and the appeal of energy missions to many academic researchers. Furthermore, while all laboratories collaborate with academic and industry partners, non-NNSA laboratory directors must be especially considerate of costs to customers when determining LDRD overhead rates. High overhead fees discourage these partnerships, limiting a laboratory's ability to disseminate the products of its research to the nation. These cost considerations prompt laboratories to elect lower LDRD and other overhead rates, rather than spend as close to the statutory limit as possible.

D. Interviewee-Reported LDRD Outcomes and Accounting Policies

To identify LDRD's major contributions to laboratory work, the Commission interviewed LDRD program managers and leadership at DOE headquarters and those laboratories visited during Phase 1. Interviewees reported a number of positive LDRD outcomes, including (a) the development of major scientific and technical programs, (b) stewardship of vital national security assets through recruitment and retention, and (c) performing cutting-edge research. Interviewees also discussed the impacts of legislative changes to LDRD's accounting policies.

Some of the claims presented in this section remain to be assessed fully, and are presented here as interviewee-reported outcomes. The Commission is aware of criticisms of the LDRD program and will continue its own investigation of LDRD during Phase 2, independently analyzing LDRD's benefits to laboratory vitality, achievement of DOE missions, and the nation.

1. Development of New Program Areas

Interviewees attribute the success and development of many noteworthy laboratory programs to LDRD investments. For competitively awarded programs such as the Joint Center for Energy Storage Research at Argonne, the Joint Bioenergy (JBEI) Institute program at Lawrence Berkeley, and the Energy Frontier Research Center led by NREL, laboratory leadership invested LDRD funds to build the foundational expertise needed to implement these programs. These programs were seeded by relatively small early investments that produced large returns in follow-on funding, a useful metric of LDRD's impact and mission alignment. For example, the $250 million JBEI program at Berkeley—established in 2007—arose from $484,000 in LDRD funding that began in the years prior, and has helped translate many inventions to the private energy industry. Under the direction of former Lawrence Berkeley Director and former Secretary of Energy Steven Chu, Lawrence Berkeley's LDRD program actively encouraged and awarded projects that focused on renewable energy technologies. These projects brought together a core team of researchers and developed the technical foundations that allowed laboratory leadership to argue strongly for JBEI's placement at the laboratory. In FY 2008, Lawrence Berkeley secured not only the JBEI program but the $500 million contract for the Energy Bioscience Institute (EBI), an internationally competed Institute funded by British Petroleum. The laboratory's ability to successfully compete for both JBEI and EBI stemmed directly from earlier LDRD projects, and Director Chu's decision to invest LDRD funding in renewable energy. Other major programs cited by interviewees as supported by early-stage LDRD include the Molecular Foundry at Lawrence Berkeley, both the original Advanced Photon Source and its upgrade at Argonne, and work on the Human Genome Project.

LDRD allows laboratories to develop capabilities proactively. As leaders of large scientific and technical enterprises, laboratory directors are well-positioned to discern potential future mission challenges in the areas of energy, science, and national security. In the 1990s, laboratory leadership at Sandia identified the growing importance of biosciences to the nation's long-term, strategic interests, and used LDRD to begin establishing a core technical capability in biosciences.[116] These early investments prepared Sandia to participate in DOE initiatives in bioenergy and chemical-biological nonproliferation and enabled Sandia to respond to advances in biosciences and growing national security concerns over the threat of biological and chemical weapons. Today, programmatic work at Sandia related to biosciences, energy, safety, security, and defense totals \$50–60 million, and Sandia continues to invest LDRD funds in the biosciences.[117]

2. Recruitment and Retention, Especially at NNSA and Other Non-SC Laboratories

Though U.S. nuclear policy has shifted from weapons production to stockpile stewardship, sustaining U.S. nuclear weapons expertise remains a high national security priority. NNSA laboratories heavily rely on LDRD programs to support laboratory efforts to recruit the workforce and develop necessary technical skills to carry out the NNSA's mission of stewarding the nation's nuclear security and weapons programs. Technical expertise in nuclear weapons science exists exclusively within the NNSA laboratories, and that expertise can only be preserved by recruiting, training, and retaining new staff.

A substantial proportion of post-doctoral researchers at NNSA laboratories are supported by LDRD and many are transitioned to full-time staff. Table 8 shows large proportions of the post-docs at all three NNSA laboratories both recruited and retained through LDRD programs. Interviewees from both DOE headquarters and laboratories concur in emphasizing the criticality of LDRD to support recruitment and retention for the nuclear security mission.

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[116] As reported through correspondence with representatives from Sandia National Laboratories.

[117] Ibid.

Table 8. LDRD Recruitment/Retention Metrics at NNSA Laboratories (FY 2008–FY 2012)

	Sandia	Lawrence Livermore*	Los Alamos
Post-doctorates supported by LDRD	56%	51%	59%
LDRD post-doctorates converted to full-time staff	77%	74%	49%

*Data for LLNL collected for FY 2010-FY 2013. Provided by NNSA.

Overall, LDRD supported 26.3% of the total post-doc population at the DOE laboratories in FY 2014.[118] Non-NNSA laboratories also recruit through LDRD. Many early career staff at the laboratories visited during Phase 1 of the Commission's study relayed the importance of LDRD, citing the ability to pursue research through LDRD as an important factor in their decision to work at the laboratories. Table 9 presents LDRD support of post-docs in FY 2013 broken down by laboratory. At non-SC laboratories in FY 2013, LDRD programs support 50% of the total post-doc population (594 of 1186 post-doctoral students, as tabulated below). Since LDRD programs provide laboratory staff the opportunity to pursue new research concepts, laboratories where those opportunities are scarcer must make greater use of flexible LDRD funds to recruit talented new researchers.

Table 9. Post-Doctorates Supported by LDRD at National Laboratories, FY 2013

Laboratory	% of Total Post-Doctorate Population	# of Post-Doctorates
Savannah (EM)	64%	7
Los Alamos (NNSA)	57%	343
Idaho (NE)	46%	6
Lawrence Livermore (NNSA)	46%	111
Sandia (NNSA)	45%	97
NREL (EERE)	29%	30
Pacific Northwest (SC)	26%	69
Argonne (SC)	25%	101
Brookhaven (SC)	16%	27
Lawrence Berkeley (SC)	13%	88
Oak Ridge (SC)	12%	68
Princeton Plasma Physics (SC)	10%	2
SLAC (SC)	9%	12
Ames (SC)	2%	1

Source: Data provided by Department of Energy, Office of Science. Fermilab and NETL did not support LDRD programs during FY 2013.

[118] DOE, *Fiscal Year 2014 Report to Congress on LDRD at the DOE National Laboratories* (Washington, DC: DOE, 2014).

3. Innovative and Cutting-Edge Research Benefits

In addition to supporting program development and recruitment, LDRD merit-review ensures a competitive award process that increases the likelihood of awards with broader research impacts. One of the LDRD's stated objectives is to support high-risk, potentially high reward R&D, and the program's funding flexibility and investigator-driven proposal system lets laboratories capture and support innovative ideas of high value and merit when they arise. The Commission is interested in how the LDRD proposal and review processes differs between laboratories, and is currently gathering additional data on how these processes impact program outputs.

DOE collects three metrics to measure LDRD's scientific productivity: number of peer review publications, patents, and invention disclosures.[119] These metrics are published by the DOE CFO's Office in its annual report to Congress on LDRD. LDRD projects at some laboratories produce a disproportionately large volume of scientific output when compared to the percentage of funds dedicated. For example, given information in Lawrence Livermore's annual reports for FY 2007 through FY 2013, 526 of 1,126 patents filed by Lawrence Livermore between FY 1999 and FY 2013 arose out of LDRD-associated projects.[120] Even though LDRD was less than 6% to 8% of the laboratory's funding each year, close to half of the laboratory's patents stemmed from LDRD work.[121]

The impact of the LDRD program cannot be captured completely through metrics such as follow-on funding, recruitment statistics, or measures of scientific productivity. Certain advances and scientific outputs of LDRD can only be captured through a broader understanding of how LDRD supports future programmatic activities. At Lawrence Livermore, for example, LDRD investments advanced high pressure physics techniques, measurement capabilities, and analytical tools to compare the performance of new and aged plutonium samples. Lawrence Livermore used these techniques to find that the plutonium pits in the nation's stewarded weapons could last longer than previously expected, effectively extending the lifetime of the nuclear stockpile. These findings contributed to the decision to scrap plans to build the Modern Pit Facility, estimated to cost $4–10 billion. Interviewees reported the impacts of this LDRD project as one of the largest successes of the stewardship program, due to dramatic savings on costly life extension programs. LDRD outcomes like these are not always evident through official reported metrics, but are nonetheless an important product of LDRD programs.

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[119] As a metric of LDRD outcomes, some individual laboratories track the amount of subsequent programmatic funding that follows from research conducted through LDRD, but DOE does not collect this data centrally.

[120] Lawrence Livermore National Laboratory, LDRD annual reports for FYs 2007 through 2013.

[121] Based on the percentage cap on LDRD funding during that fiscal year.

4. Congressional Changes to LDRD Accounting Policies

Accounting policies for LDRD have fluctuated over time as a result of legislative changes. In FY 2006, Congress raised the percentage cap on LDRD to 8% and mandated that LDRD projects pay fully burdened overhead costs, reflecting diverging opinions between the House and Senate Committees on the implementation and oversight of laboratory LDRD programs.[122] The addition of overhead costs means that projects cost roughly twice what they did previously, with the result that any given amount of money will only support half as many projects under the new rules. The FY 2014 reduction in the LDRD cap from 8% to 6% has also negatively impacted the availability of LDRD funds at some laboratories. Interviewees have reported cuts to the size of recruitment and retention programs, number of projects, and funding to specific types of projects, such as exploratory research as a result of this FY 2014 change. Some interviewees have equated the burdening of LDRD as a "double-counting" of overhead, since LDRD itself is one element of a laboratory's overhead fee. Interviewees argue that this burdening reduces program outputs and suggest that since LDRD is designed to improve the laboratory's overall performance like other overhead charges, LDRD should be exempt from paying full burden as it has been historically. However, the Commission also recognizes that LDRD projects incur real costs in terms of staff time consumed, facilities occupied, and resources used, and that the argument to unburden LDRD must address these associated costs. In the next phase of its study, the Commission will further explore the impacts of the fully burdened overhead rates and the changes in the annual expenditure cap, weighing arguments both for and against modifying LDRD's accounting policies.

E. Summary Observations and Preliminary Recommendations

Based on its work to date, the Commission's preliminary observations include:

- LDRD is an important element to sustained programmatic success at the laboratories, with a long history of support and accomplishments dating back to 1954 when it was first authorized by the Congress.
- LDRD is the sole source of discretionary research funding under the control of the laboratory director for the National Laboratories. Formal requirements for LDRD projects ensure that projects are selected competitively and that they

[122] Members of the House Committee argued in House Report 109-86 (FY 2006 Energy and Water Development Appropriations Act) that charging LDRD as an indirect General and Administrative (G&A) cost placed a "disproportionate additional overhead burden on direct program activities." The Committee members argued that since LDRD activities were "functionally identical" to programmatic projects, projects funded by LDRD should pay fully burdened overheard. During the same year, the Senate defended in Senate Report 109-84 (FY 2006 Energy and Water Appropriations Bill) the value and execution of the LDRD program, citing that "the LDRD program continues to provide solutions to future science and defense mission needs before program problems or requirements are even realized," and complimented the Department's "strong and effective management of the LDRD program."

explore innovative, new areas of research that are not already covered by existing programs.

- LDRD is an important recruitment and retention tool for the National Laboratories. This is especially critical at the NNSA laboratories, which must attract new staff into the laboratories in order to maintain a highly-trained workforce to support the NNSA's nuclear weapons missions.
- While Federal oversight is important to ensure non-duplication of effort and proper alignment of LDRD with DOE's mission, the Commission believes that the statutory requirement that every LDRD project be individually reviewed by DOE—which in FY 2014 totaled 1,662 projects—may be excessively costly and burdensome to both Departmental and laboratory staff. The Commission intends to review whether approaches such as periodic audits or a sampling of each year's project pool may be sufficient for compliance and a more efficient alternative to current oversight.
- LDRD is a resource for supporting cutting edge exploratory research prior to the time that a research program is identified and developed by DOE. It is worthwhile and appropriate for multiple LDRD projects at various labs to be funded in the same topic area as a means of exploring different potential paths for an ultimate program in the field. These small, early stage projects provide valuable insights for the peer-review, strategic assessments by DOE as part of the program planning process.

In Phase 2 of its study, the Commission will continue its study of LDRD, in the following directions:

- Further analysis of the current oversight and Federal management of the LDRD program.
- Validation of interviewee-reported outcomes of the LDRD program.
- Further analysis of the impacts of the overhead burden and the FY 2014 drop in the percentage cap on the effectiveness of the program.
- Benchmarking LDRD at the National Laboratories against discretionary research programs at other Federal research institutions, such as NIST, NASA, and DOD.

7. Appropriate Size of National Laboratories to Meet National Needs

Congress asked the Commission to address whether the National Laboratories “are appropriately sized to meet the Department’s energy and national security missions.”[123] Tackling the question of optimal size of a R&D portfolio is not an easy task, especially as it pertains to seventeen networked yet separate R&D institutions. The Commission, however, has taken initial steps to answer this question in the aggregate by analyzing DOE’s role and funding support in the context of national R&D activities. Important questions related to size are whether the appropriate proportion of DOE funding is sent to the laboratories relative to academia and industry and whether the laboratory complex is operating as efficiently and effectively as possible, both of which will be explored further in Phase 2.

A. Federal Support of R&D

The Commission sees continued Federal support of R&D as critical to the future of the national S&T enterprise and the nation’s economy and security. The most recent report of the American Association for the Advancement of Science (AAAS) on U.S. R&D funding notes that S&T are “key drivers of economic growth, improved human health, and increasing quality of life,” and that “economists estimate half or more of economic growth over the past several decades is due to technical progress.”[124]

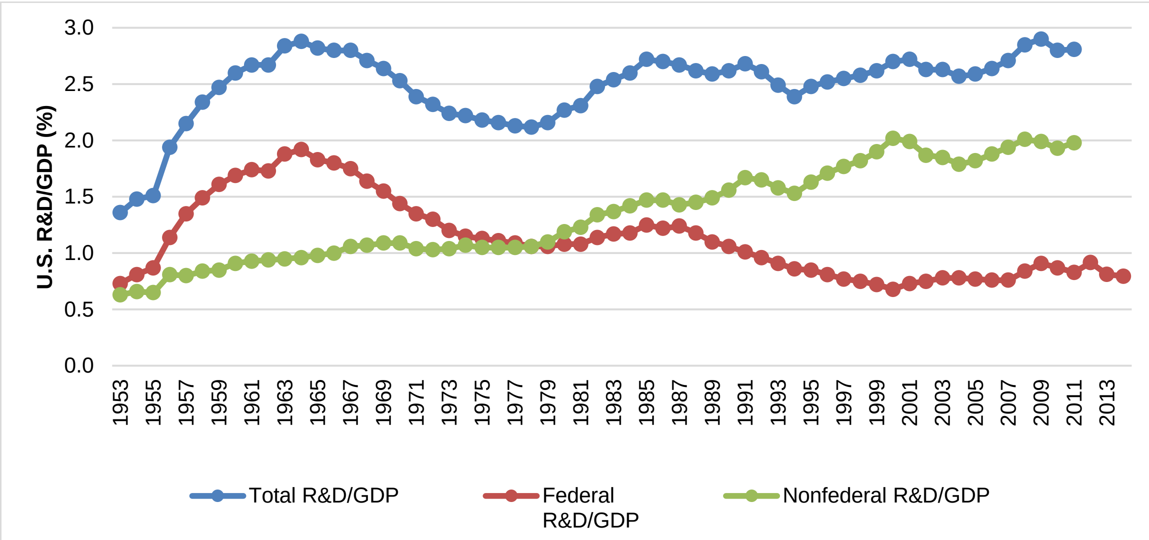
Because of its importance, several reports have called for maintained, if not increased, funding to all types of Federal R&D. One such report released in September 2014 details how R&D, especially basic research, funding is an investment in future success and that sustained funding is necessary for maximum benefit from this research.[125] While total funding to R&D as a percentage of gross domestic product (GDP) has increased slightly over the past 30 years, Federal R&D funding as a percentage of GDP has decreased at roughly the same rate that non-Federal funding has increased (Figure 7). Simultaneously, the United States has fallen from first to tenth in

[123]Section 319, Congressional Appropriations Act (2014). See Appendix B.

[124]M. Hourihan, et al. *AAAS Report XXXIX: Research and Development FY 2015* (Washington, DC: American Association for the Advancement of Science, 2014), 20.

[125]Committee on New Models for U.S. Science & Technology Policy, *Restoring the Foundation: The Vital Role of Research in Preserving the American Dream* (Cambridge, MA: American Academy of Arts & Sciences, 2014).

the world for R&D investment as a percentage of GDP.[126] *Restoring the Foundation* recommended the President and Congress increase R&D and provide a long-term investment strategy in order to reestablish dominance internationally.[127] Such calls for sustained R&D funding are not new, [128] but with current budget realities, the Commission is concerned that the United States is at risk of losing critical capabilities and its competitive advantage. This risk is especially worrisome as it also pertains to national security.[129]



Source: Science and Engineering Indicators 2014 (1953–2011), AAAS Report XXXIX (2012–2014 Federal R&D), OMB GDP and Deflators (2012–2014 GDP values).

Notes: Values for Federal R&D/GDP in 2012–2014 were calculated with Federal R&D values from AAAS Report XXXIX: Research and Development FY 2015 and with GDP values from OMB Gross Domestic Product and Deflators Used in the Historical Tables: 1940–2019. Values for 2014 Budget and 2013 and 2014 GDP are estimates. Absent from this figure are values for total and non-Federal R&D 2012–2014.

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[126] According to Organisation for Economic Cooperation and Development (OECD), *Main Science and Technology Indicators*.

[127] Recommendations in *Restoring the Foundation* include strong reauthorization bills like the America COMPETES Acts of 2007 and 2010, and for the President and Congress to "adopt multiyear appropriations for agencies." Without these changes, the authors calculate a $639 billion shortfall in funding of basic research by 2032 when compared to sustained funding from 1975–1992.

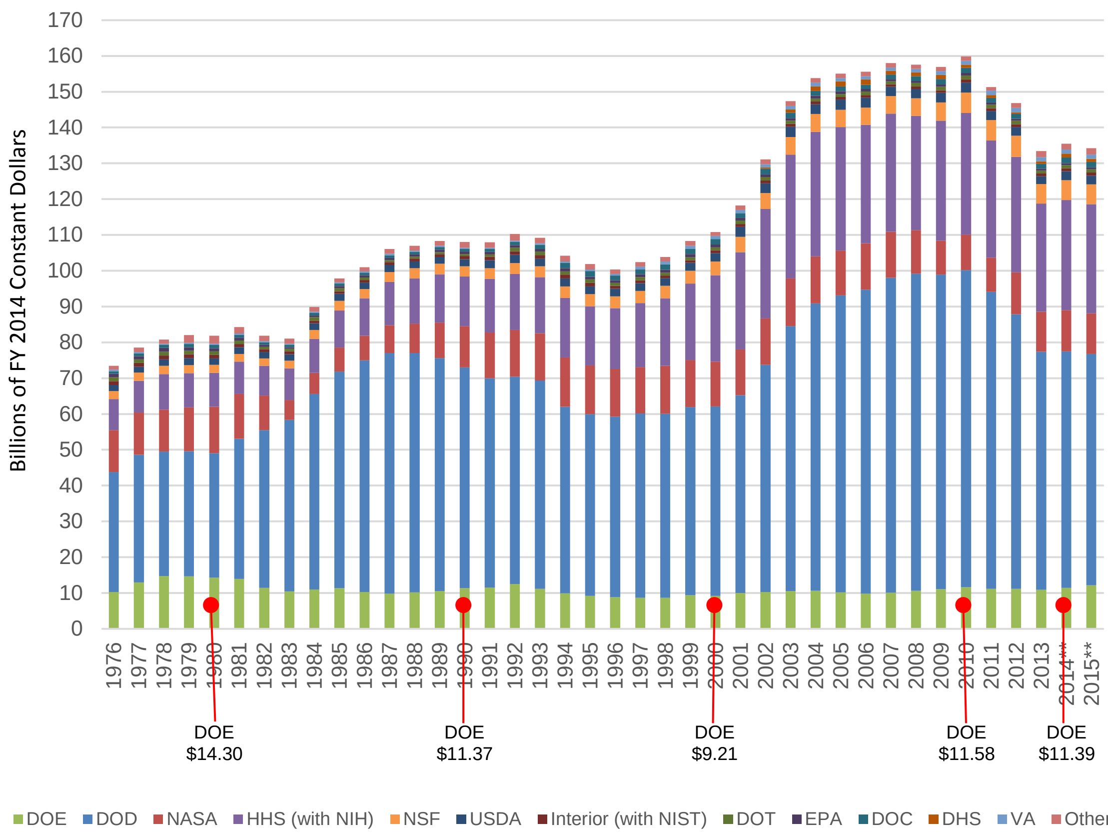
[128] Two National Academies reports *Rising above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future* (2007) and its update (2010), thoroughly detail how a decrease in support to R&D would negatively impact the nation. Additionally, in remarks at a National Academy of Sciences Annual Meeting, the President called for the United States to spend 3% of GDP on science and technology in a 2009 speech, a goal the United States has not attained (http://www.whitehouse.gov/the_press_office/Remarks-by-the-President-at-the-National-Academy-of-Sciences-Annual-Meeting/).

[129] N. R. Augustine, "The Eroding Foundation of National Security," *Strategic Studies Quarterly* 8 (4, Winter 2014).

Figure 7. Ratio of U.S. Research and Development to Gross Domestic Product (Percent), 1953–2014

B. DOE R&D as a Percentage of Total U.S. Investment in R&D

By looking at Federal R&D spending by agency, DOE's portion of Federal R&D funding can be explored. According to historical data from AAAS, the amount of Federal R&D support to DOE has stayed relatively constant since 1976 in constant dollars (Figure 8).[130]



Source: AAAS Historical Trends in Federal R&D, Total R&D by Agency 1976–2015.

** Values for 2014 and 2015 are latest estimates; values for 2015 are from the President's budget request.

Figure 8. Trends in R&D by Agency (billions of constant FY 2014 dollars), 1976–2015

Further, the percentage of Federal R&D spending bound for DOE has remained between 6 and 9% over the past 20 years, but this percentage was slightly higher from

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[130] These values are all in constant 2014 dollars. Although the overall budget of the Department has remained relatively stable, specific DOE program funding has varied over the years due to changing strategic priorities within the Department's four missions: energy, science, environmental cleanup, and national security.

1976-1995, ranging from 9 to 18% of Federal R&D spending (Figure 9). At 8.1% of Federal R&D spending and Federal R&D spending at 0.81% of the nation's GDP, DOE R&D budget is 0.066%, or less than one thousandth, of the nation's GDP.[131] Based on 2013 data, the Federal budget spends about 9 cents per capita on DOE R&D per day, while Americans spend about $1.08 per day on store-bought alcohol products and 94 cents per day on tobacco products.[132]

Considering the impact the laboratories have had and the size of DOE's funding relative to other R&D expenditures, the Commission does not feel that the overall funding level for the DOE is too large. Indeed, it could be questioned whether that level is too low given the important missions of the DOE and the National Laboratories. The Commission sees the National Laboratories as a national asset that must be sustained. The challenge is to make the DOE laboratory system as efficient as possible, in order to get the maximum amount of technical R&D work performed given the available level of Federal funding.

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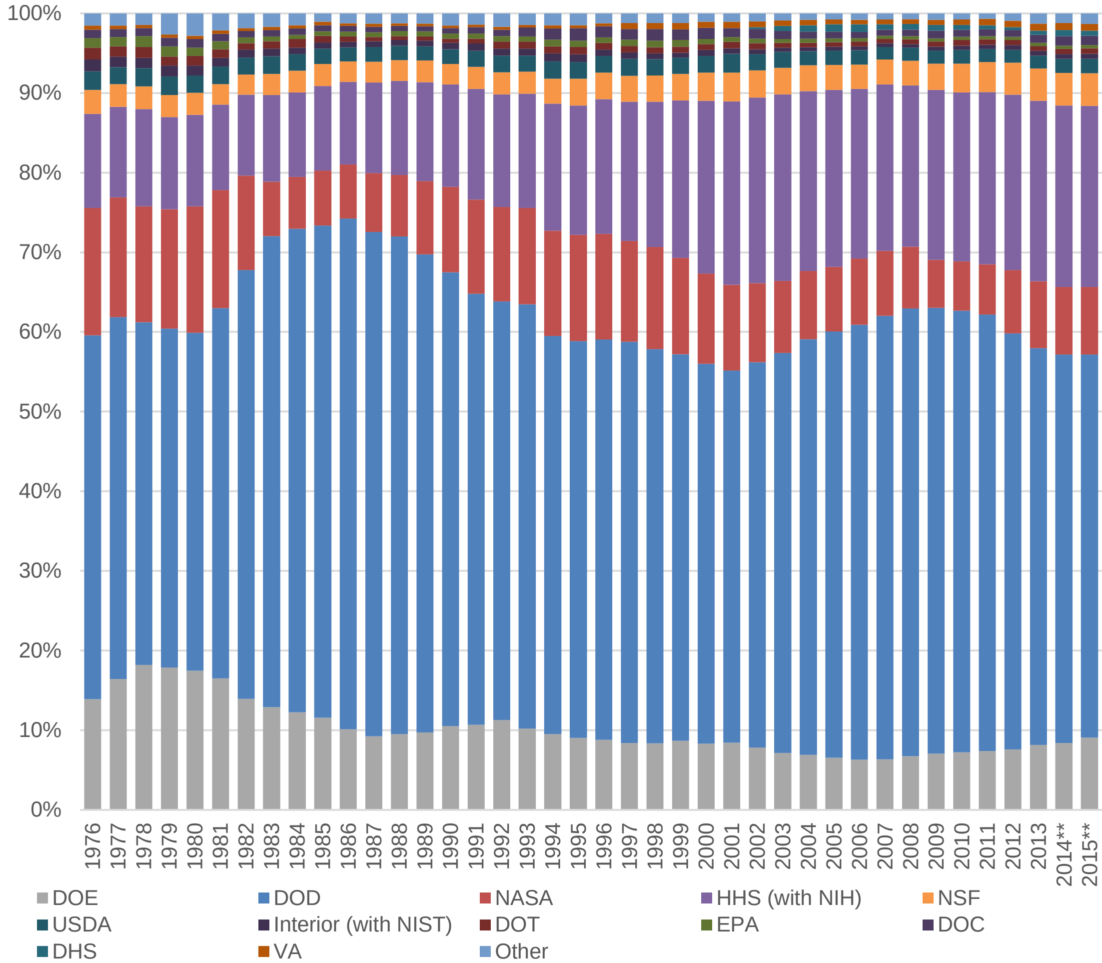
[131] DOE percentage of Federal R&D spending from *AAAS Historical Trends in Federal R&D, Total by Agency 1976—2015* (http://www.aaas.org/page/historical-trends-federal-rd). Percentage of Federal R&D of U.S. GDP from *AAAS Report XXXIX: Research and Development FY 2015*. These values are from FY 2013. More recent values (FY 2014 and FY 2015) are estimates. The most recent values for percentage of total national R&D are for 2011. In 2011, DOE R&D funding was 7.39% of Federal R&D funding, and Federal R&D funding was 29.5% of total U.S. R&D funding. Thus, DOE R&D funding was 2.18% of total national R&D expenditures.

[132] U.S. 2013 population estimate accessed from the U.S. Census Bureau's website (www.census.gov) on January 16, 2014. U.S. Department of Commerce Bureau of Economic Analysis Table 2.5.5 Personal Consumption Expenditures by Function (www.bea.gov) was used to calculate amount spent on store-bought alcohol and tobacco products. For comparison, the DOE 2014 estimated budget costs about 10 cents for each American per day. Augustine makes a similar argument with regard to biomedical basic research in a December 2014 Op-Ed, "Is Biomedical Research a Good Investment?" *The Journal of Clinical Investigation* 124:12, 2014.



Source: AAAS Historical Trends in Federal R&D, Total R&D by Agency 1976–2015.
* Values for 2014 and 2015 are estimates, which are subject to change.

Figure 9. Percentage of Federal R&D Funds to Each Agency, 1976–2015

C. Importance of DOE User Facilities

During the five laboratory site visits conducted to date, the Commission found that a significant portion of the users who conduct research at the user facilities are funded by sources other than DOE, most prominently NSF and NIH.[133] The size of individual laboratories and the laboratory complex as a whole are partially due to the demand for these user facilities by researchers from across the country and supported by other Federal agencies.

[133]User facilities are discussed further in Chapter 5.

D. Relationship between Cost Considerations and Management Efficiencies and Size of the Laboratory Complex

The Commission has found several areas that relate to size of workforce across the DOE laboratory complex that require more investigation in Phase 2. For example, it will be helpful to compare relative staffing levels across the complex and benchmark these figures against other R&D institutions. Areas to explore include personnel devoted to administrative support functions and user facilities. During the site visits the Commission heard examples of changes in staff size at the laboratories that have occurred in recent years. Some of these reductions in force were occasioned by budget cuts, and others were associated with new contracts that had higher overhead costs and, therefore, lower remaining program budgets.[134]

Another area the Commission plans to research further concerns the size of DOE's oversight staff in its headquarters and field offices. For example, the recent report *A New Foundation for the Nuclear Security Enterprise* describes an overly large staff at NNSA field offices.[135] Each DOE laboratory has a field office that serves as the local Federal oversight of the laboratory. When comparing NNSA field offices to other parts of DOE, the authors note that the average size of an SC Field Office is 0.1 field office employee per 100 M&O employees (laboratory employees). The same value at NNSA sites is between 6 and 14 times larger: Lawrence Livermore 1.4, Los Alamos 0.8, Sandia 0.7, and Savannah River Site 0.6.[136]

This Commission has found in its Phase 1 interviews and site visits some evidence of the "wasteful and ineffective transactional oversight" referenced in the Augustine/Mies Report.[137] Not all field offices and not all oversight employees conduct their work in this way, but based on Phase 1 findings, the Commission supports the adoption of recommendation 16.2 in the Augustine/Mies Report:

> The Secretary [of Energy] and Director should eliminate transactional oversight in areas where there are better mechanisms for certifying

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[134] Due to the M&O contract change in 2008 and its associated increase in costs, LLNL laid off about 2000 employees. LBNL discussed a human resources tracking system that involves a consortium of five laboratories, and Argonne National Laboratory had a reduction in force in FY 2014 that resulted in an estimated $12 million in cost savings. Certain laboratories have created workforce management systems to predict workforce needs. More information about the Enterprise Modeling headed by Cliff Shang at LLNL can be found at: https://str.llnl.gov/october-2013/shang.

[135] Congressional Advisory Panel on the Governance of the Nuclear Security Enterprise. *A New Foundation for the Nuclear Security Enterprise*.

[136] Ibid. Note that although Savannah River National Laboratory is not stewarded by NNSA the Savannah River Site includes a NNSA-run site office (Savannah River Field Office).

[137] Ibid.

contractor performance, to include reform of the field office's staffing levels and performance criteria.[138]

In Phase 2, the Commission will examine site office staffing size and alternatives to the current level of decision approval requirements.

E. Summary Observations and Preliminary Recommendations

Based on its work to date, the Commission's preliminary observations include:

- The question of whether the DOE laboratory complex is appropriately sized is difficult to answer. An important, related question is whether, given its current size and configuration, the laboratory complex is operating as efficiently and effectively as possible.
- Federal funding of DOE's annual R&D budget has been relatively constant over the past 40 years. The Department's share of Federal R&D spending has remained at less than 9% for the past 20 years, falling from a high of 18% in the 1970s and 1980s. Considering the impact the laboratories have had and the level of DOE funding relative to other R&D expenditures, the Commission does not feel that the overall funding to the DOE is too large.
- The appropriate size of each individual laboratory is determined by DOE through a strategic review of duplication, alignment, and quality of R&D.

In Phase 2 of its study, the Commission intends to explore allocation of funding and measures that could increase efficiencies within the DOE laboratory system. As reported by the Augustine/Mies panel, the size of DOE's oversight and support structure may offer opportunities for significant streamlining, especially in the NNSA. This issue will be further explored across the laboratory complex during Phase 2.

[138] Note that "Director" in this recommendation references the current position of "Under Secretary for Nuclear Security and NNSA Administrator." The Augustine/Mies Report details changes to the current configuration of the NNSA, which would change this position to "Director" to mimic the structure of the other DOE Offices.

8. Conclusion

The National Laboratories have been the subject of numerous studies over the past 40 years. Since the 1995 Galvin Report, the state of the laboratories seems to have remained the regular topic *du jour*, generating a constant stream of reports and high-profile studies. Past studies have observed similar findings in many of the topic areas investigated in this report, and have often made similar recommendations. Just in the past few years, a number of external studies have reported on topics including research quality and management at NNSA and DOE oversight of contractor operations. Some of these studies are still in progress, such as an NRC study of governance structures at the NNSA laboratories. Concurrently, SEAB is studying many of the same issues as well as laboratory infrastructure and LDRD.

The volume of studies reporting similar recommendations raises questions as to whether persistent issues are truly inexorable, or linger on as a result of a failure to implement previous recommendations. Furthermore, the National Laboratories are a complex system of systems, and to know the laboratories one must understand that complexity. Studies of the National Laboratories make sense of this complexity by focusing on a subset of issues, topics, or laboratories. By shining light repeatedly on the same areas of improvement, these studies produce a sense of systemic inertia without always identifying root causes of persistent problems. Isolated issues become generalized across the complex, blazing prominently without sense of diversity or context, while the successes and achievements of individual laboratories dissolve into the background. This is not to say problems do not exist, as the Commission notes in this report's preliminary findings and recommendations. Rather, the Commission stresses that certain themes speak to many topic areas, and that some issues may be better understood not in isolation but as symptoms of systemic issues. To this end, the Commission frames its observations within a broader fabric of recurring themes.

A. Recurring Themes

A number of themes arose through the course of the Commission's study to date:

- Expanded Purpose of National Laboratories: Today, the laboratories serve not just the missions of the DOE, but the Nation as a whole.
- Recommendations Should Reflect the Laboratories' Diversity of Size, Practices, and Mission Scope: Laboratories are non-uniform, and recommendations must account for this diversity

- Partnership between DOE and its National Laboratories is both important and complicated. Means must be found to establish and maintain a strong partnership between DOE and the laboratories. Many issues stem from the overly conservative management of risk.

These themes are explored in the subsections that follow.

1. Expanded Purpose of National Laboratories

Even before the establishment of DOE, the National Laboratories were already serving national interests as the research engines of the Manhattan Project and Atomic Energy Commission. Today, the seventeen laboratories continue to provide substantial value to the nation, whether through support of DOE missions, stewardship of scientific user facilities, work for other Federal agencies, or collaborations with universities and industry. As it moves into the next phase of its study, the Commission will further assess how the National Laboratories might be additionally supported to bring the benefits of its research to both DOE and the broader community, recognizing that today's laboratories are indeed national in scope and reach.

2. Recommendations Must Account for Diversity of Size, Practices, and Mission Scope

The 17 laboratories are diverse, ranging widely in size, business practices, and mission scope. Each of the six DOE Offices that steward National Laboratories have distinct and unique mission needs, and consequently meet the responsibilities of laboratory stewardship differently. The diversity of the laboratories is shaped by these differences, and few broadly generalizable observations can be made that apply to all seventeen.

The Commission is interested in identifying broader themes that affect the entire complex, but recognizes how findings and recommendations may not apply equally to all laboratories. Part of the reason the Commission is committed to visiting all seventeen laboratories is to better identify the unique challenges faced by individual laboratories, and better understand how the National Laboratories function as a system. Single-program Office of Science laboratories face different challenges than the larger NNSA laboratories or multi-program Office of Science laboratories, while some DOE Offices and laboratories have a record of implementing better management practices than others. The Commission reiterates its observation that the Department could benefit greatly from a strategic plan for the laboratories that takes not just an Office but complex-wide view. As it makes further observations and recommendations in the next phase, the Commission will continue to recognize how non-uniformity across the laboratories is an important consideration in how the laboratories perform their work.

3. Partnership between DOE and Its National Laboratories is both Important and Complicated

Over the course of its study, the Commission has become increasingly concerned with what it sees as evidence of a damaged relationship between DOE and its laboratories. Historically, the National Laboratories were designed to deliver the highest quality product to the public by drawing on the management expertise, flexibility, and best practices of academia and the private sector. For many years, however, a combination of heavy micromanagement, overly prescriptive regulations, and a culture of risk aversion has distanced DOE from its stewarded laboratories and inhibited the intended benefits of public-private partnership.

The Commission emphasizes three critical components to ensure a healthy relationship between the National Laboratories and DOE: trust, communication, and a clear understanding of each party's roles. Many of the issues concerning the National Laboratories can be traced to failings in these three areas. Representatives internal to the DOE laboratory complex have emphasized that success of the laboratories hinges on true partnership and effective communication with DOE.

Lack of trust in the laboratories manifests itself in micromanagement and extreme risk aversion by DOE that negatively impact laboratory productivity and efficiency in ways identified in both this and previous studies. Three of these recurring issues—overly burdensome audits and inspections, duplicative Orders and Directives, and the 'atomization' of laboratory budgets into smaller and smaller reporting categories—will be a major focus of this Commission's next phase.

Strong communication is key to any working relationship, and evidence of inadequate communication between the National Laboratories, DOE, and Congress is alarming. The Commission notes that laboratories have historically been largely kept out of key decision-making processes, especially as they pertain to strategic planning of the agency. In recent years, DOE has made efforts to more fully involve the laboratories in these processes, and the Commission recommends finding ways of institutionalizing these improvements. Congressional appropriators asserted that DOE could better highlight the successes and uniqueness of its laboratories to external stakeholders, and Congress specifically. Last year's National Lab Day on the Hill was one step in that direction, and the Commission encourages further opportunities for increased interface.

Finally, the government-owned, contractor-operated FFRDC model functions best when the government and contractor roles are clearly defined. Broadly speaking, DOE and other customers should define the "what" and grant laboratories the flexibility to determine the "how." Contractors should be trusted, and held accountable, to apply best management and business practices of the private sector to fulfill the missions defined by DOE and other customers. Over time, however, increased involvement of DOE in laboratory operations has restricted the ability of laboratories to apply these practices, forcing laboratories to prioritize compliance over mission delivery.

Many of the symptoms of this deteriorated relationship are operational in nature, and the Commission believes that looking more closely at root causes may provide insights into how to improve the laboratories more broadly. As it moves into Phase 2 of its study, the Commission will assess the issues and areas of effective management not covered in this report, and continue to identify ways to strengthen the relationship between DOE and the National Laboratories.

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This Commission was established to review the effectiveness of the Department of Energy's National Laboratories. While the Commission believes significant improvements to and progress in many aspects of laboratory management and governance need to be made, these issues do not detract from the National Laboratories' remarkable contributions to the American public. In the next phase of its study, the Commission expects to identify additional areas in need of improvement, root causes of long-standing issues, and findings on which to base strong recommendations. At this stage, the Commission takes the view that the National Laboratories are an irreplaceable and invaluable national asset, supporting both the missions of DOE and the prosperity of the Nation.

Appendix A.
Commissioner Biographies

Jared L. Cohon, Co-Chair

Dr. Jared L. Cohon is President Emeritus and University Professor of Civil and Environmental Engineering and Engineering and Public Policy at Carnegie Mellon University.

Dr. Cohon served as president of Carnegie Mellon for 16 years (1997–2013). He came to Carnegie Mellon from Yale, where he was Dean of the School of Forestry and Environmental Studies from 1992 to 1997. He started his teaching and research career in 1973 at Johns Hopkins, where he was a faculty member in the Department of Geography and Environmental Engineering for 19 years. He also served as Assistant and Associate Dean of Engineering and Vice Provost for Research at Johns Hopkins. Dr. Cohon earned a B.S. degree in civil engineering from the University of Pennsylvania in 1969 and a Ph.D. in civil engineering from the Massachusetts Institute of Technology in 1973.

An author, coauthor, or editor of one book and more than 80 professional publications, Dr. Cohon is an authority on environmental and water resource systems analysis, an interdisciplinary field that combines engineering, economics and applied mathematics. He has worked on water resource problems in the United States, South America and Asia and on energy facility siting, including nuclear waste shipping and storage. In addition to his academic experience, he served in 1977 and 1978 as legislative assistant for energy and the environment to the late Honorable Daniel Patrick Moynihan, United States Senator from New York. President Bill Clinton appointed Dr. Cohon to the Nuclear Waste Technical Review Board in 1995 and appointed him as chairman in 1997. His term on the Board ended in 2002. President George W. Bush appointed Dr. Cohon in 2002 to the Homeland Security Advisory Council and President Barack Obama reappointed him in 2009. His term on the Council ended in 2013.

In 2009, Dr. Cohon was named a Distinguished Member of the American Society of Civil Engineers. He was elected to the National Academy of Engineering and to the American Academy of Arts and Sciences in 2012. He has received honorary degrees from the Korean Advanced Institute for Science and Technology, the University of Pittsburgh and Carnegie Mellon.

TJ Glauthier, Co-Chair

TJ Glauthier, President of TJG Energy Associates, LLC, is an advisor to energy companies and public agencies. He held two Presidential appointments in the Clinton Administration: at the White House as Associate Director of the Office of Management and Budget from 1993–1998, and as the Deputy Secretary and COO of the Department of Energy from 1999–2001. He also served on President Obama's transition team in 2008.

Mr. Glauthier was a member of the Congressional Advisory Panel on the Governance of the Nuclear Security Enterprise in 2013-2014.

He currently serves on two corporate boards of directors: EnerNOC, a provider of energy intelligence software, and VIA Motors, a manufacturer of electric drive pickup trucks and vans. He is an advisor to Booz Allen Hamilton's energy practice and has also served on advisory boards for numerous energy technology companies.

In addition, he is a member of the Policy and Global Affairs Committee of the National Research Council, the Precourt Institute at Stanford University, and the Lawrence Berkeley National Laboratory Advisory Board.

Earlier, Mr. Glauthier was CEO of the Electricity Innovation Institute, an affiliate of EPRI, and spent twenty years in management consulting. He is a graduate of Claremont McKenna College and the Harvard Business School.

Norman R. Augustine

Norman R. Augustine was raised in Colorado and attended Princeton University where he graduated with a BSE in Aeronautical Engineering, magna cum laude, and an MSE. He was elected to Phi Beta Kappa, Tau Beta Pi and Sigma Xi.

In 1958 Mr. Augustine joined the Douglas Aircraft Company in California where he worked as a Research Engineer, Program Manager and Chief Engineer. Beginning in 1965, he served in the Office of the Secretary of Defense as Assistant Director of Defense Research and Engineering. He joined LTV Missiles and Space Company in 1970, serving as Vice President, Advanced Programs and Marketing. In 1973 he returned to the government as Assistant Secretary of the Army and in 1975 became Under Secretary of the Army, and later Acting Secretary of the Army. Joining Martin Marietta Corporation in 1977 as Vice President of Technical Operations, he was elected as CEO in 1987 and chairman in 1988, having previously been President and COO. He served as president of Lockheed Martin Corporation upon the formation of that company in 1995, and became CEO later that year. He retired as chairman and CEO of Lockheed Martin in August 1997, at which time he became a Lecturer with the Rank of Professor on the faculty of Princeton University where he served until July 1999.

Mr. Augustine was Chairman and Principal Officer of the American Red Cross for nine years, Chairman of the Council of the National Academy of Engineering, President and Chairman of the Association of the United States Army, Chairman of the Aerospace Industries Association, and Chairman of the Defense Science Board. He is a former President of the American Institute of Aeronautics and Astronautics and the Boy Scouts of America. He is a current or former member of the Board of Directors of ConocoPhillips, Black & Decker, Proctor & Gamble and Lockheed Martin, and was a member of the Board of Trustees of Colonial Williamsburg. He is a Regent of the University System of Maryland, Trustee Emeritus of Johns Hopkins and a former member of the Board of Trustees of Princeton and MIT. He is a member of the Advisory Board to the Department of Homeland Security, was a member of the Hart/Rudman Commission on National Security, and has served for 16 years on the President's Council of Advisors on Science and Technology. He is a member of the American Philosophical Society and the Council on Foreign Affairs, and is a Fellow of the National Academy of Arts and Sciences and the Explorers Club.

Mr. Augustine has been presented the National Medal of Technology by the President of the United States and received the Joint Chiefs of Staff Distinguished Public Service Award. He has five times received the Department of Defense's highest civilian decoration, the Distinguished Service Medal. He is co-author of The Defense Revolution and Shakespeare In Charge and author of Augustine's Laws and Augustine's Travels. He holds 23 honorary degrees and was selected by Who's Who in America and the Library of Congress as one of "Fifty Great Americans" on the occasion of Who's Who's fiftieth anniversary. He has traveled in over 100 countries and stood on both the North and South Poles of the earth.

Wanda M. Austin

Dr. Wanda M. Austin is president and chief executive officer of The Aerospace Corporation, a leading architect for the Nation's national security space programs. The Aerospace Corporation has nearly 4,000 employees and annual revenues of more than $850 million. She assumed this position on January 1, 2008. She is internationally recognized for her work in satellite and payload system acquisition, systems engineering, and system simulation.

Dr. Austin served on President Obama's Review of Human Spaceflight Plans Committee in 2009, was appointed to the Defense Science Board in 2010, and was appointed to the NASA Advisory Council in 2014.

Dr. Austin earned a bachelor's degree in mathematics from Franklin & Marshall College, master's degrees in systems engineering and mathematics from the University of Pittsburgh, and a doctorate in systems engineering from the University of Southern California.

Dr. Austin is a fellow of the AIAA, and is a member of the National Academy of Engineering, the International Academy of Astronautics, and the American Academy of Arts and Sciences. She also serves on the Board of Directors of the Space Foundation, and on the Board of Trustees for the University of Southern California and the National Geographic Society.

Dr. Austin has received numerous awards and citations. Among them are the National Intelligence Medallion for Meritorious Service, the Air Force Scroll of Achievement, and the National Reconnaissance Office Gold Medal. In 2010 she received the AIAA von Braun Award for Excellence in Space Program Management, and is a recipient of the 2012 Horatio Alger Award, the 2012 NDIA Peter B. Teets Industry Award, and the 2014 USC Viterbi Distinguished Alumni Award.

Dr. Austin is committed to inspiring the next generation to study the STEM disciplines and to make science and engineering preferred career choices. Under her guidance, the corporation has undertaken a number of initiatives in support of this goal, including participation in MathCounts, US FIRST Robotics, and Change the Equation.

Charles Elachi

Dr. Charles Elachi is the Director of the Jet Propulsion Laboratory and Vice President of California Institute of Technology. He is a Professor of Electrical Engineering and Planetary Science at Caltech.

Dr. Elachi was born April 18, 1947, in Lebanon. He received a B.S. in physics from the University of Grenoble, France and the Diplome Ingenieur in engineering from the Polytechnic Institute, Grenoble in 1968 where he graduated first in the class, and M.S. and Ph.D. degrees in electrical sciences from the California Institute of Technology, Pasadena in 1969 and 1971, respectively. He later received an MBA from USC (1979) and an M.S. degree in geology from UCLA (1983).

Dr. Elachi taught “The Physics of Remote Sensing” at the California Institute of Technology from 1982 to 2000. Dr. Elachi was Principal Investigator on numerous research and development studies and flight projects sponsored by the National Aeronautics and Space Administration (NASA). He was Principal Investigator for the Shuttle Imaging Radar series (SIR-A in 1981, SIR-B in 1984, and SIR-C in 1994), was a Co-Investigator on the Magellan imaging radar, is presently the Team Leader of the Cassini Titan Radar experiment and a Co-Investigator on the Rosetta Comet Nucleus Sounder Experiment. He is the author of over 230 publications in the fields of space and planetary exploration, Earth observation from space, active microwave remote sensing, electromagnetic theory and integrated optics, and he holds several patents in those fields. In addition, he has authored three textbooks in the field of remote sensing. One of these textbooks has been translated into Chinese.

In his 40 year career at JPL, Dr. Elachi played the lead role in developing the field of spaceborne imaging radar which led to Seasat, SIR-A, SIR-B, SIR-C, Magellan, SRTM and the Cassini Radar. He received numerous national and international awards for his leadership in this field.

During the late 80’s and 90’s as the Director of Space and Earth Science programs, Dr. Elachi was responsible for the definition and development of numerous JPL flight instruments and missions for Solar System Exploration, the Origins program, Earth Observation and Astrophysics.

In the mid to late 90’s, Dr. Elachi chaired a number of national and international committees which developed NASA roadmaps for the exploration of neighboring Solar Systems (1995), our Solar System (1997) and Mars (1998).

Paul A. Fleury

Dr. Paul A. Fleury is the Frederick William Beinecke Professor of Engineering and Applied Physics, and Professor of Physics at Yale University. He is the founding Director of the Yale Institute for Nanoscience and Quantum Engineering. He served as Dean of Engineering at Yale from 2000 until 2008. Prior to joining Yale Dr. Fleury was Dean of the School of Engineering at the University of New Mexico from January 1996, following 30 years at AT&T Bell Laboratories. At Bell Laboratories he was director of three different research divisions covering physics, materials and materials processing research between 1979 and 1996. During 1992 and 1993 he was Vice President for Research and Exploratory Technology at Sandia National Laboratories

Dr. Fleury is the author of more than 130 scientific publications on non-linear optics, spectroscopy and phase transformations in condensed matter systems and has co-edited three books. He is a Fellow of the American Physical Society and the American Association for the Advancement of Science; and a member of the National Academy of Engineering, the National Academy of Sciences and a Fellow of the American Academy of Arts and Sciences. He received the 1985 Michelson-Morley Award and the 1992 Frank Isakson Prize of the American Physical Society for his research on optical phenomena and phase transitions in condensed matter systems.

Dr. Fleury has been a member of numerous National Research Council study panels, including that of the 2007 National Nanotechnology Initiative review, “A Matter of Size”, as well as the 2013 NNI triennial review committee. He has served on the Secretary of Energy’s “Laboratory Operations Board” and the University of California President’s Council on the National Laboratories. He has also served on review committees for Brookhaven, Lawrence Berkeley, Oak Ridge, Sandia and Los Alamos National Laboratories and for six years as a member of the Visiting Committee for Advanced Technology for NIST. He is currently active Sandia, ORNL and LANL advisory committees in addition to his service on the Board on Physics and Astronomy and the Laboratory Assessment Board of the National Academy of Sciences. He received his Bachelor of Science and Master of Science degrees in 1960 and 1962 from John Carroll University, and his doctorate from the Massachusetts Institute of Technology in 1965, all in physics.

Susan J. Hockfield

A noted neuroscientist, Dr. Susan J. Hockfield was the first life scientist to serve as President of the Massachusetts Institute of Technology, where she holds a faculty appointment as Professor of Neuroscience in the Department of Brain and Cognitive Sciences. Before assuming the presidency of MIT in 2004, she was Provost at Yale University, where she had taught since 1985 and had also served as Dean of the Graduate School of Arts and Sciences. A graduate of the University of Rochester, Dr. Hockfield received her Ph.D. from the Georgetown University School of Medicine, carrying out her dissertation research in neuroscience at the National Institutes of Health. An elected member of the American Academy of Arts and Sciences and an elected fellow of the American Association for the Advancement of Science, Dr. Hockfield holds honorary degrees from Brown University, Duke University, Mount Sinai School of Medicine, Tsinghua University (Beijing), University of Edinburgh, University of Massachusetts Medical School, University of Pierre and Marie Curie (Paris), University of Rochester and the Watson School of Biological Sciences at Cold Spring Harbor Laboratory in New York. Additionally, she holds a jointly-awarded honorary degree from the New University of Lisbon, the Technical University of Lisbon and the University of Porto, Portugal. She serves as a director of the General Electric Company and Qualcomm Incorporated, a trustee of the Boston Symphony Orchestra and the Council on Foreign Relations, and is a member of the board of the World Economic Forum Foundation.

In 2006 under Dr. Hockfield's leadership, MIT launched a major energy initiative, capitalizing on the Institute's deep strength in science, engineering, architecture, management and economics to pioneer the leading edge of energy and environmental research, from visionary policy recommendations to technological breakthroughs.

Richard A. Meserve

Dr. Richard A. Meserve is Senior of Counsel with Covington & Burling LLP, a large multi-national law firm. He recently stepped down as the President of the Carnegie Institution for Science after 11 years at the helm. The Carnegie Institution conducts basic research in biology, astronomy and geophysics.

Dr. Meserve served as Chairman of the US Nuclear Regulatory Commission from 1999-2003. He was the principal executive officer of the federal agency with responsibility for ensuring public health and safety in the operation of nuclear power plants and in the usage of nuclear materials. He served as Chairman under both Presidents Clinton and Bush and lead the NRC in responding to the terrorism threat that came to the fore after the 9/11 attacks. Before joining the NRC, Dr. Meserve was a partner in Covington & Burling LLP. With his Harvard law degree, received in 1975, and his Ph.D. in applied physics from Stanford, awarded in 1976, he devoted his legal practice to technical issues arising at the intersection of science, law, and public policy. Early in his career, he served as legal counsel to the President's science adviser, and was a law clerk to Justice Harry A. Blackmun of the United States Supreme Court and to Judge Benjamin Kaplan of the Massachusetts Supreme Judicial Court. He received his undergraduate degree from Tufts University in 1966.

Dr. Meserve has served on numerous legal and scientific committees over the years, including many established by the National Academies of Sciences and Engineering. He served on the Blue-Ribbon Commission on America's Nuclear Future established by DOE Secretary Chu at the direction of the President and currently serves as Chairman of the International Nuclear Safety Group, which is chartered by the International Atomic Energy Agency. Among other affiliations, he is a member of the National Academy of Engineering, American Philosophical Society, and Sigma Xi, and he is a Fellow of the American Academy of Arts and Sciences, the American Association for the Advancement of Science, the American Physical Society, and the Phi Beta Kappa Society. He is a Foreign Member of the Russian Academy of Sciences.

Dr. Meserve also serves on the Council of the National Academy of Engineering and of the American Academy of Arts and Sciences. He is on the Board of Directors of PG&E Corporation, Duke Energy Corporation, and the Universities Research Association, Inc. He is a member of the Visiting Committee to the MIT Department of Nuclear Science and Engineering and to the Harvard School of Engineering and Applied Physics.

Cherry A. Murray

Dr. Cherry A. Murray is Dean of Harvard University's School of Engineering and Applied Sciences; John A. and Elizabeth S. Armstrong Professor of Engineering and Applied Sciences; and Professor of Physics. Previously, Murray served as principal associate director for science and technology at Lawrence Livermore National Laboratory from 2004-2009 and was president of the American Physical Society in 2009. Before joining Lawrence Livermore, Murray was Senior Vice President of Physical Sciences and Wireless Research after a 27 year long career at Bell Laboratories Research.

Dr. Murray was elected to the National Academy of Sciences in 1999, to the American Academy of Arts and Sciences in 2001, and to the National Academy of Engineering in 2002. She has served on more than 100 national and international scientific advisory committees, governing boards and National Research Council panels and as a member of the National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling. She is currently chair of the National Research Council Division of Engineering and Physical Science.

As an experimentalist, Dr. Murray is known for her scientific accomplishments in condensed matter and surface physics. She received her B.S. in 1973 and her Ph.D. in physics in 1978 from the Massachusetts Institute of Technology. She has published more than 70 papers in peer-reviewed journals and holds two patents in near-field optical data storage and optical display technology.

Appendix B.
Congressional Charge

The following is the text of Consolidated Appropriations Act, 2014, Section 319,

Sec. 319. (a) Establishment - The Secretary shall establish an independent commission to be known as the “Commission to Review the Effectiveness of the National Energy Laboratories.” The National Energy Laboratories refers to all Department of Energy and National Nuclear Security Administration national laboratories.

(b) Members-

(1) The Commission shall be composed of nine members who shall be appointed by the Secretary of Energy not later than May 1, 2014, from among persons nominated by the President’s Council of Advisors on Science and Technology.

(2) The President’s Council of Advisors on Science and Technology shall, not later than March 15, 2014, nominate not less than 18 persons for appointment to the Commission from among persons who meet qualification described in paragraph (3).

(3) Each person nominated for appointment to the Commission shall—

(A) be eminent in a field of science or engineering; and/or

(B) have expertise in managing scientific facilities; and/or

(C) have expertise in cost and/or program analysis; and

(D) have an established record of distinguished service.

(4) The membership of the Commission shall be representative of the broad range of scientific, engineering, financial, and managerial disciplines related to activities under this title.

(5) No person shall be nominated for appointment to the Board who is an employee of—

(A) the Department of Energy;

(B) a national laboratory or site under contract with the Department of Energy;

(C) a managing entity or parent company for a national laboratory or site under contract with the Department of Energy; or

(D) an entity performing scientific and engineering activities under contract with the Department of Energy.

(c) Commission Review and Recommendations-

(1) The Commission shall, by no later than February 1, 2015, transmit to the Secretary of Energy and the Committees on Appropriations of the House of Representatives and the Senate a report containing the Commission's findings and conclusions.

(2) The Commission shall address whether the Department of Energy's national laboratories —

(A) are properly aligned with the Department's strategic priorities;

(B) have clear, well understood, and properly balanced missions that are not unnecessarily redundant and duplicative;

(C) have unique capabilities that have sufficiently evolved to meet current and future energy and national security challenges;

(D) are appropriately sized to meet the Department's energy and national security missions; and

(E) are appropriately supporting other Federal agencies and the extent to which it benefits DOE missions.

(3) The Commission shall also determine whether there are opportunities to more effectively and efficiently use the capabilities of the national laboratories , including consolidation and realignment, reducing overhead costs, reevaluating governance models using industrial and academic bench marks for comparison, and assessing the impact of DOE's oversight and management approach. In its evaluation, the Commission should also consider the cost and effectiveness of using other research, development, and technology centers and universities as an alternative to meeting DOE's energy and national security goals.

(4) The Commission shall analyze the effectiveness of the use of laboratory directed research and development (LDRD) to meet the Department of Energy's science, energy, and national security goals. The Commission shall further evaluate the effectiveness of the Department's oversight approach to ensure LDRD-funded projects are compliant with statutory requirements and congressional direction, including requirements that LDRD projects be distinct from projects directly funded by appropriations and that LDRD projects derived from the Department's national security programs support the national security

mission of the Department of Energy. Finally, the Commission shall quantify the extent to which LDRD funding supports recruiting and retention of qualified staff.

(5) The Commission's charge may be modified or expanded upon approval of the Committees on Appropriations of the House of Representatives and the Senate.

(d) Response by the Secretary of Energy-

(1) The Secretary of Energy shall, by no later than April 1, 2015, transmit to Committees on Appropriations of the House of Representatives and the Senate a report containing the Secretary's approval or disapproval of the Commission's recommendations and an implementation plan for approved recommendations.

Appendix C. Letter from Secretary of Energy Moniz to Senator Feinstein

The Secretary of Energy
Washington, DC 20585

May 20, 2014

The Honorable Dianne Feinstein
Chairman
Subcommittee on Energy and Water Development
Senate Committee on Appropriations
United States Senate
Washington, DC 20510

Dear Chairman:

The Department of Energy has been working to stand up the Commission to Review the Effectiveness of the National Energy Laboratories (the "Commission") pursuant to section 319 of the Consolidated Appropriations Act, 2014 (Public Law No. 113-76). In vetting availability, willingness, and conflicts of interest of proposed Commission members, the desired timeline has emerged as a focus of concern. Being sensitive to the full scope of the study and the overall availability of the Commission members, we are now planning to address the study in two phases.

In Phase 1, which the Commission plans to complete by February 1, 2015, the Commission will develop a baseline of information by focusing its review and recommendations on the matters set forth in section 319, subsection (c)(2) of the Consolidated Appropriations Act, 2014. Laboratory Directed Research and Development (LDRD) will be considered in Phase 1 as it is found to inform (c)(2)(a) and (c)(2)(c). Following the completion of Phase 1, the Commission will submit an interim report on the results of its Phase 1 work.

In Phase 2, the Commission will address the scope of subsection (c)(3), as well as an analysis of LDRD pursuant to subsection (c)(4) of the statute. After submission of the Phase 1 interim report, conversations with the Committees will inform the final scope and timeline of Phase 2.

We believe this plan will address Commission members' workload constraints and will allow the Department to deliver the intended information to the Congress. Should you have any questions or need additional information, please contact me or Mr. Joseph Levin, Associate Director for External Coordination, at (202) 586-3098.

Sincerely,

Ernest J. Moniz

cc: The Honorable Lamar Alexander
Ranking Member

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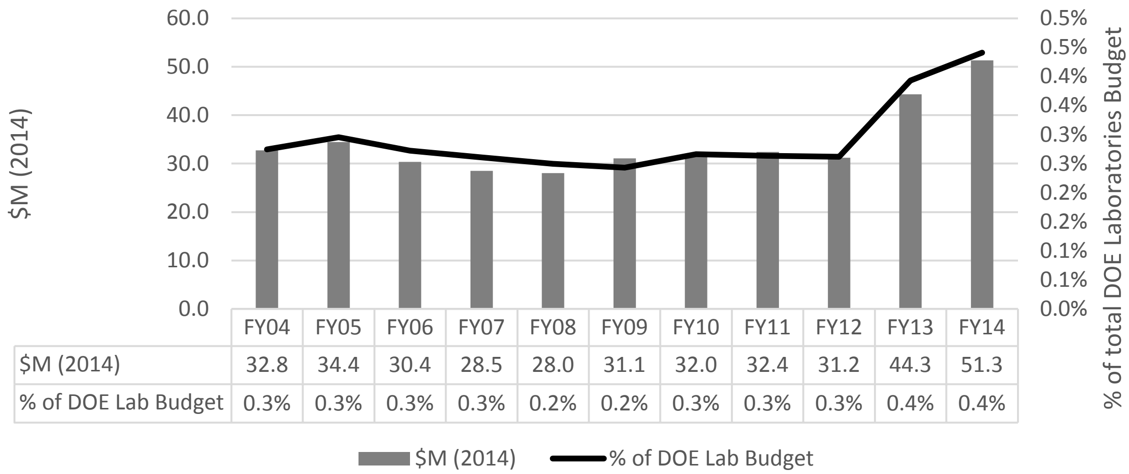
Appendix D.
Descriptions of National Laboratories

Ames National Laboratory

Established in 1947, Ames is managed by Iowa State University and stewarded by the Office of Science.



	FY04	FY05	FY06	FY07	FY08	FY09	FY10	FY11	FY12	FY13	FY14
$M (2014)	32.8	34.4	30.4	28.5	28.0	31.1	32.0	32.4	31.2	44.3	51.3
% of DOE Lab Budget	0.3%	0.3%	0.3%	0.3%	0.2%	0.2%	0.3%	0.3%	0.3%	0.4%	0.4%

Figure D-1. Ames National Laboratory Total Spending and Budget as Percentage of DOE National Laboratories Budget, FY2004-FY2014

Core Capabilities

- Condensed Matter Physics and Materials Science
- Chemical and Molecular Science
- Applied Materials Science and Engineering

Argonne National Laboratory

Established in 1946, Argonne National Laboratory is managed by the University of Chicago, Argonne LLC and stewarded by the Office of Science.

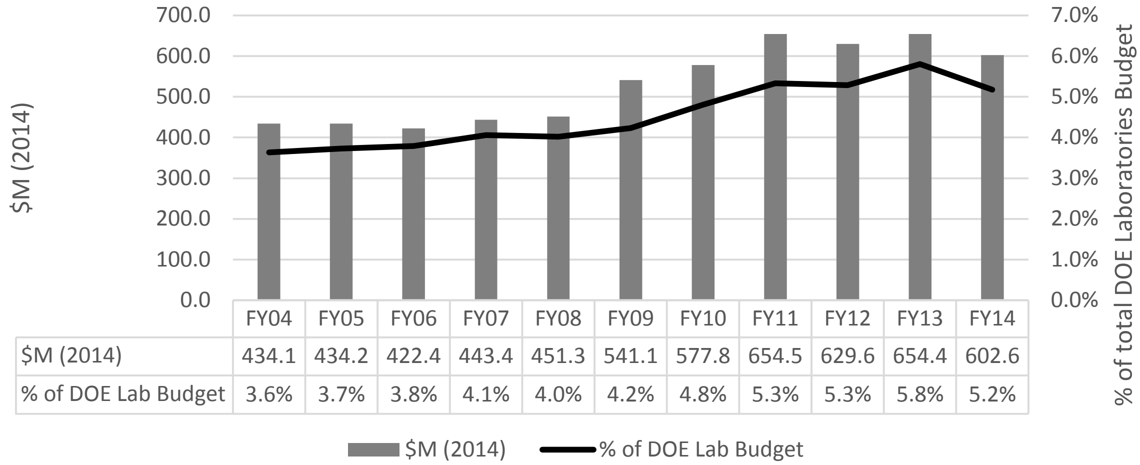


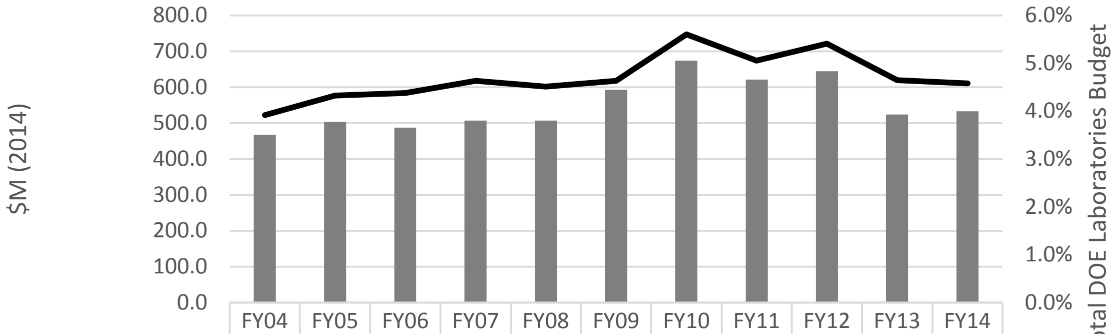
Figure D-2. Argonne National Laboratory Total Spending and Budget as Percentage of DOE National Laboratories Budget, FY2004-FY2014

Core Capabilities

- Particle Physics
- Nuclear Physics
- Accelerator Science and Technology
- Condensed Matter Physics and Materials Science
- Chemical and Molecular Science
- Applied Mathematics
- Advanced Computer Science, Visualization, and Data
- Applied Nuclear Science and Technology
- Applied Materials Science and Engineering
- Chemical Engineering
- Systems Engineering and Integration
- Large Scale User Facilities / Advanced Instrumentation

Brookhaven National Laboratory

Established in 1947, Brookhaven National Laboratory is managed by Brookhaven Science Associates, LLC and is stewarded by the Office of Science.



	FY04	FY05	FY06	FY07	FY08	FY09	FY10	FY11	FY12	FY13	FY14
$M (2014)	467.9	503.7	487.7	506.6	507.0	592.5	673.6	620.8	644.6	523.9	532.7
% of DOE Lab Budget	3.9%	4.3%	4.4%	4.6%	4.5%	4.6%	5.6%	5.1%	5.4%	4.6%	4.6%

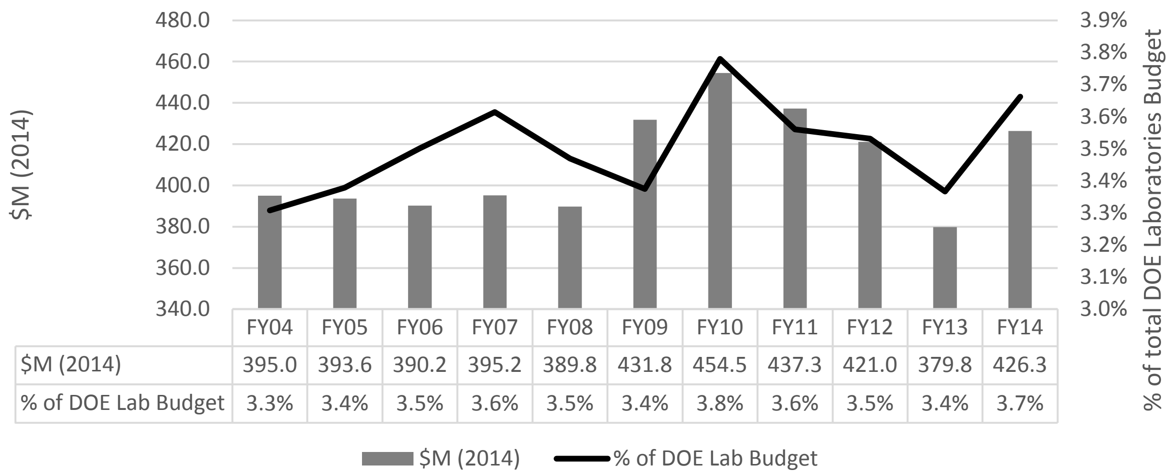
Figure D-3. Brookhaven National Laboratory Total Spending and Budget as Percentage of DOE National Laboratories Budget, FY2004-FY2014

Core Capabilities

- Particle Physics
- Nuclear Physics
- Accelerator Science and Technology
- Condensed Matter Physics and Materials Science
- Chemical and Molecular Science
- Climate Change Science
- Biological Systems Science
- Applied Nuclear Science and Technology
- Applied Materials Science and Engineering
- Chemical Engineering
- Systems Engineering and Integration
- Large Scale User Facilities / Advanced Instrumentation

Fermi National Accelerator Laboratory

Established in 1967, Fermi National Accelerator Laboratory is managed by the Fermi Research Alliance, LLC and stewarded by the Office of Science.



	FY04	FY05	FY06	FY07	FY08	FY09	FY10	FY11	FY12	FY13	FY14
$M (2014)	395.0	393.6	390.2	395.2	389.8	431.8	454.5	437.3	421.0	379.8	426.3
% of DOE Lab Budget	3.3%	3.4%	3.5%	3.6%	3.5%	3.4%	3.8%	3.6%	3.5%	3.4%	3.7%

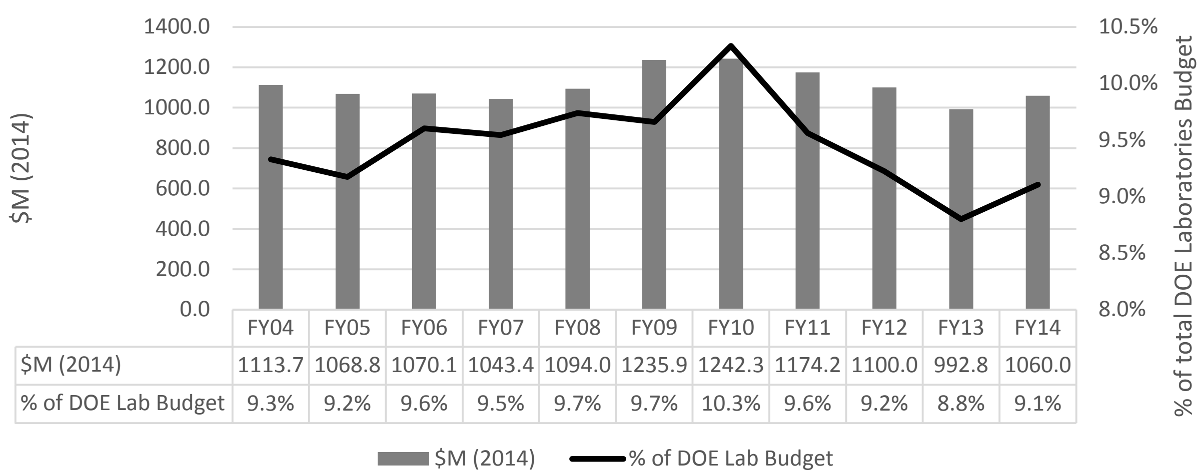
Figure D-4. Fermi National Accelerator Laboratory Total Spending and Budget as Percentage of DOE National Laboratories Budget, FY2004-FY2014

Core Capabilities

- Particle Physics
- Accelerator Science and Technology
- Large Scale User Facilities / Advanced Instrumentation

Idaho National Laboratory

Established in 1949, Idaho National Laboratory is managed by the Battelle Energy Alliance, LLC and stewarded by the Office of Nuclear Energy.



	FY04	FY05	FY06	FY07	FY08	FY09	FY10	FY11	FY12	FY13	FY14
$M (2014)	1113.7	1068.8	1070.1	1043.4	1094.0	1235.9	1242.3	1174.2	1100.0	992.8	1060.0
% of DOE Lab Budget	9.3%	9.2%	9.6%	9.5%	9.7%	9.7%	10.3%	9.6%	9.2%	8.8%	9.1%

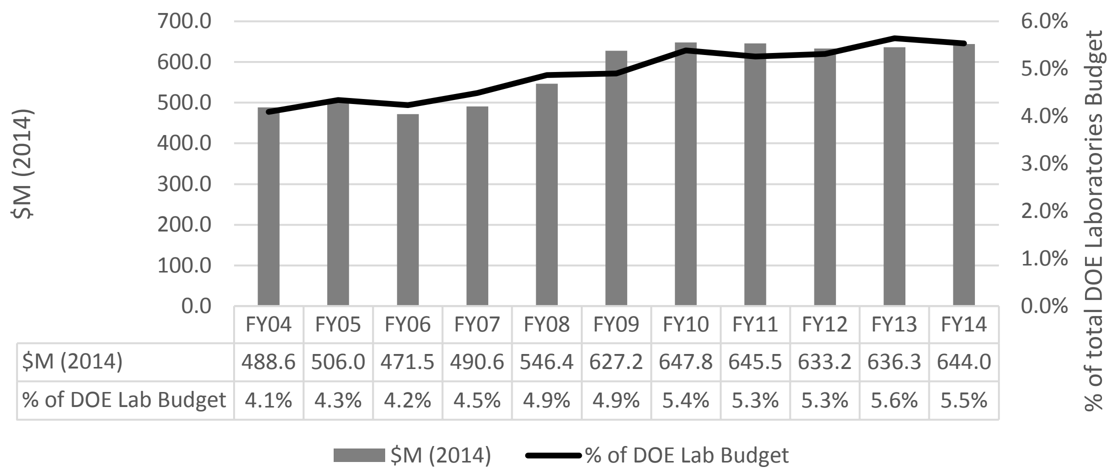
Figure D-5. Idaho National Laboratory Total Spending and Budget as Percentage of DOE National Laboratories Budget, FY2004-FY2014

Core Capabilities

- Modeling and Simulation
- Fuel Cycle Research and Development
- Light Water Reactor Sustainability
- Advanced Reactor Research and Development
- Space Nuclear Systems and Technology
- Next Generation Nuclear Program Research and Development
- Nuclear Nonproliferation
- Critical Infrastructure Protection
- Industrial Control Systems Cyber Security
- Electric Grid Resiliency
- Explosives Detection and Testing
- Armor and Defense Systems
- Hybrid Energy Systems
- Non-traditional Hydrocarbons
- Advanced Energy Storage Performance Science
- Clean Energy and Water
- Biofuels Feedstock Science and Engineering
- Energy Critical Materials
- Clean Energy Grid Integration Modeling and Validation
- Energy Systems Diagnostics and Control
- Materials Performance Science

Lawrence Berkeley National Laboratory

Established in 1931, Lawrence Berkeley National Laboratory is managed by the University of California and stewarded by the Office of Science.



	FY04	FY05	FY06	FY07	FY08	FY09	FY10	FY11	FY12	FY13	FY14
$M (2014)	488.6	506.0	471.5	490.6	546.4	627.2	647.8	645.5	633.2	636.3	644.0
% of DOE Lab Budget	4.1%	4.3%	4.2%	4.5%	4.9%	4.9%	5.4%	5.3%	5.3%	5.6%	5.5%

Figure D-1. Lawrence Berkeley National Laboratory Total Spending and Budget as Percentage of DOE National Laboratories Budget, FY2004-FY2014

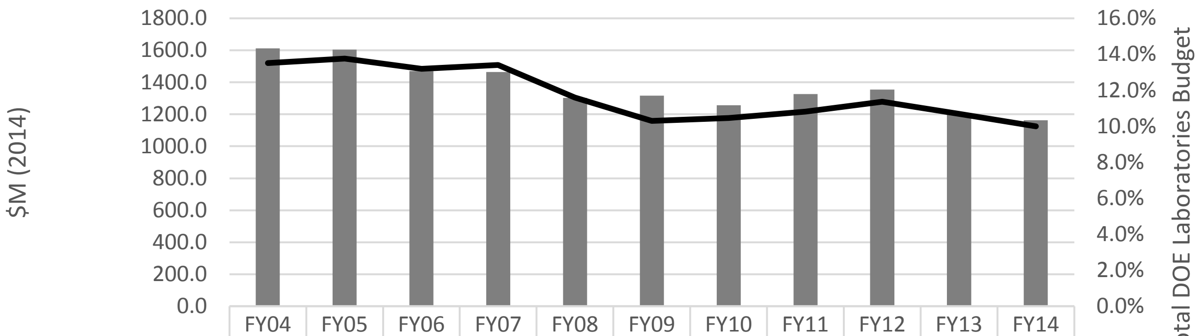
Core Capabilities

- Particle Physics
- Nuclear Physics

- Accelerator Science and Technology
- Condensed Matter Physics and Materials Science
- Chemical and Molecular Science
- Biological Systems Science
- Environmental Subsurface Science
- Climate Change Science
- Applied Mathematics
- Advanced Computer Science, Visualization, and Data
- Computational Science
- Applied Nuclear Science and Technology
- Applied Materials Science and Engineering
- Chemical Engineering
- Systems Engineering and Integration
- Large Scale User Facilities / Advanced Instrumentation

Lawrence Livermore National Laboratory

Established in 1952, Lawrence Livermore National Laboratory is managed by Lawrence Livermore National Security, LLC and stewarded by the National Nuclear Security Administration.



	FY04	FY05	FY06	FY07	FY08	FY09	FY10	FY11	FY12	FY13	FY14
$M (2014)	1612.6	1603.8	1469.6	1464.8	1302.3	1317.2	1257.0	1327.2	1355.0	1206.2	1163.5
% of DOE Lab Budget	13.5%	13.8%	13.2%	13.4%	11.6%	10.3%	10.5%	10.8%	11.4%	10.7%	10.0%

Figure D-7. Lawrence Livermore National Laboratory Total Spending and Budget as Percentage of DOE National Laboratories Budget, FY2004-FY2014

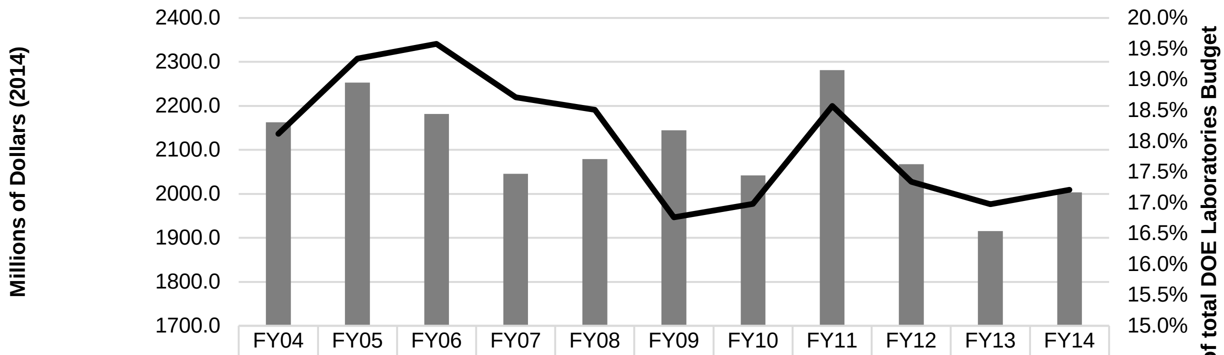
Core Capabilities

- High Performance Computing
- High Energy-Density Science
- Nuclear Physics and Radiochemistry
- Radiation Detection Systems
- Actinide Materials
- Energetic Materials
- Computational Geomechanics and Seismology
- Computational Mathematics

- Computational Engineering
- Climate Change and Atmospheric Science
- Biodetection and Diagnotics
- Computational Materials and Chemistry
- Engineered Materials
- Chemical and Isotopic Signatures
- Lasers and Optical Materials
- All-Source Intelligence Analysis
- Nuclear Design

Los Alamos National Laboratory

Established in 1943, Los Alamos National Laboratory is managed by Los Alamos National Security, LLC and stewarded by the National Nuclear Security Administration.



	FY04	FY05	FY06	FY07	FY08	FY09	FY10	FY11	FY12	FY13	FY14
$M (2014)	2163.0	2252.9	2181.5	2045.8	2079.0	2144.5	2041.7	2281.0	2067.1	1915.1	2003.1
% of DOE Lab Budget	18.1%	19.3%	19.6%	18.7%	18.5%	16.8%	17.0%	18.6%	17.3%	17.0%	17.2%

$M (2014) — % of DOE Lab Budget

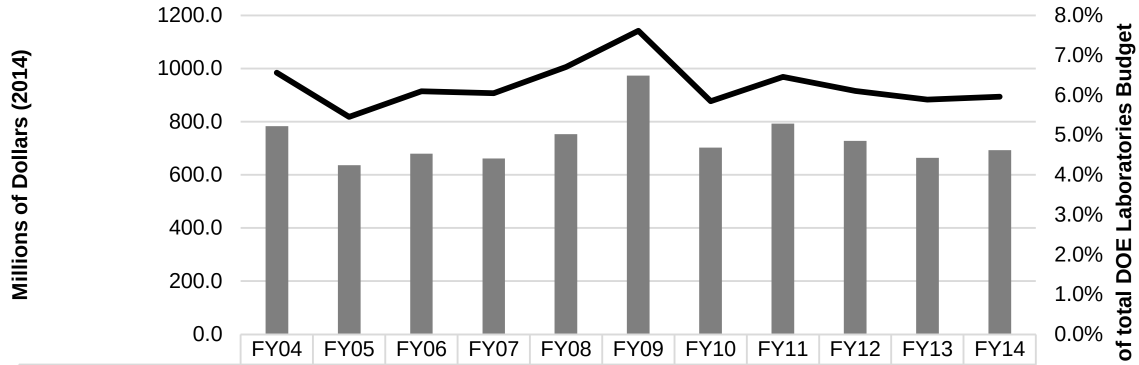
Figure D-8. Los Alamos National Laboratory Total Spending and Budget as Percentage of DOE National Laboratories Budget, FY2004-FY2014

Core Capabilities

- Nuclear Weapons Stockpile
- Nuclear Nonproliferation
- Emerging Global Threats
- Energy Security
- Physics
- Astrophysics and Cosmology
- Materials Science
- Sensors and Materials Signatures
- Plutonium and Actinide Science
- High-Performance Computing

National Energy Technology Laboratory

Established in 1910, the National Energy Technology Laboratory is a government-owned, government-operated laboratory with no managing contractor. It is operated by the Office of Fossil Energy.



	FY04	FY05	FY06	FY07	FY08	FY09	FY10	FY11	FY12	FY13	FY14
$M (2014)	783.1	635.7	679.2	661.5	753.1	973.7	702.9	792.6	727.6	664.0	693.4
% of DOE Lab Budget	6.6%	5.5%	6.1%	6.1%	6.7%	7.6%	5.8%	6.5%	6.1%	5.9%	6.0%

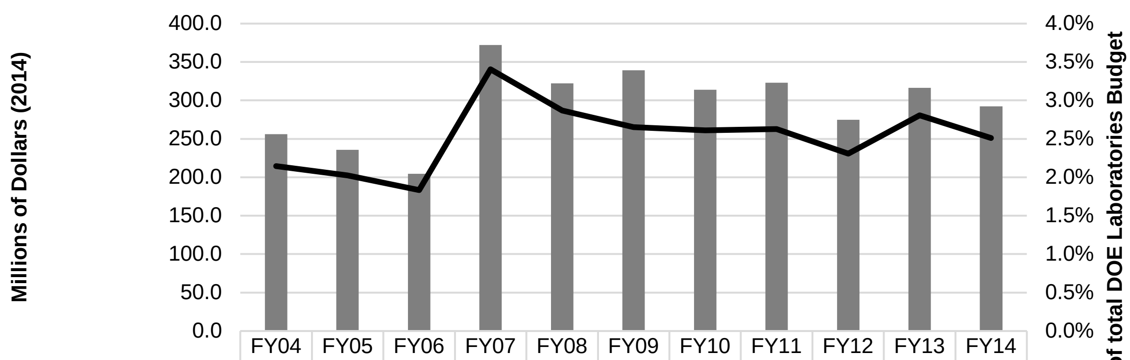
Figure D-9. National Energy Technology Laboratory Total Spending and Budget as Percentage of DOE National Laboratories Budget, FY2004-FY2014

Core Capabilities

- Chemical and molecular science
- Computational science
- Applied geosciences and engineering
- Applied materials science and engineering
- Chemical engineering
- Mechanical design and engineering
- Cyber and information sciences
- Decision science and risk analysis
- Systems Engineering and Integration

National Renewable Energy Laboratory

Established in 1977, NREL is managed by the Alliance for Sustainable Energy, LLC and stewarded by the Office of Energy Efficiency and Renewable Energy.



	FY04	FY05	FY06	FY07	FY08	FY09	FY10	FY11	FY12	FY13	FY14
$M (2014)	255.9	235.8	204.5	372.0	322.0	339.1	313.7	322.8	274.9	316.5	292.3
% of DOE Lab Budget	2.1%	2.0%	1.8%	3.4%	2.9%	2.7%	2.6%	2.6%	2.3%	2.8%	2.5%

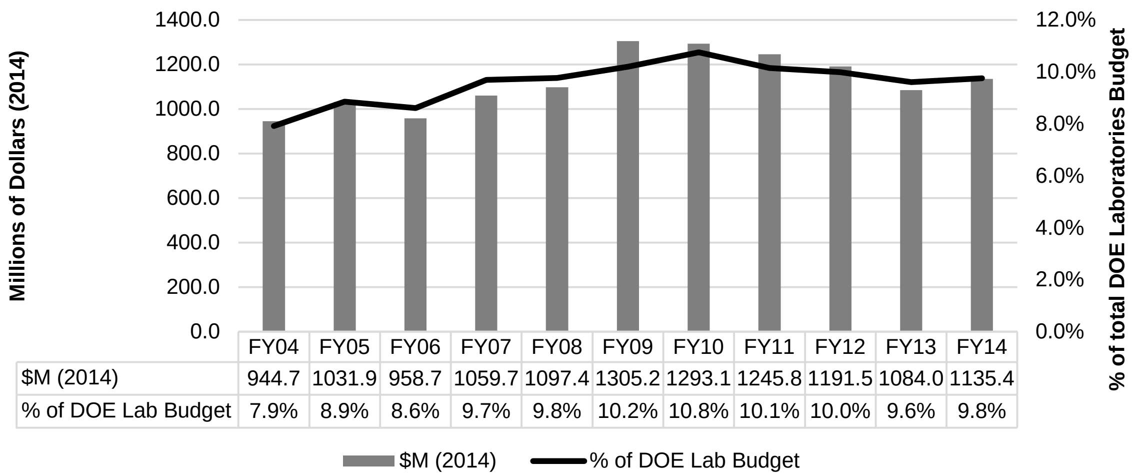
Figure D-10. National Renewable Energy Laboratory Total Spending and Budget as Percentage of DOE National Laboratories Budget, FY2004-FY2014

Core Capabilities

- Energy Systems Integration
- Materials & Chemistry Science and Technology
- Energy Systems Integration
- Materials and Chemistry Science and Technology
- Bioenergy Science and Technology
- Mechanical and Thermal Engineering
- Strategic Energy Analysis

Oak Ridge National Laboratory

Established in 1943, Oak Ridge National Laboratory is managed by UT-Battelle, LLC and stewarded by the Office of Science.



	FY04	FY05	FY06	FY07	FY08	FY09	FY10	FY11	FY12	FY13	FY14
$M (2014)	944.7	1031.9	958.7	1059.7	1097.4	1305.2	1293.1	1245.8	1191.5	1084.0	1135.4
% of DOE Lab Budget	7.9%	8.9%	8.6%	9.7%	9.8%	10.2%	10.8%	10.1%	10.0%	9.6%	9.8%

Figure D-11. Oak Ridge National Laboratory Total Spending and Budget as Percentage of DOE National Laboratories Budget, FY2004-FY2014

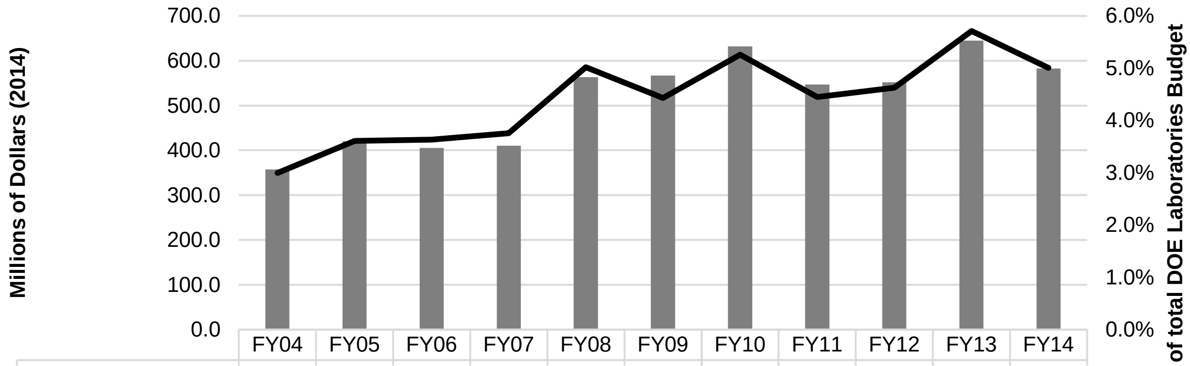
Core Capabilities

- Nuclear Physics
- Accelerator Science and Technology
- Plasma and Fusion Energy Sciences
- Condensed Matter Physics and Materials Science
- Chemical and Molecular Science
- Climate Change Science
- Biological Systems Science
- Environmental Subsurface Science
- Advanced Computer Science, Visualization, and Data
- Computational Science
- Applied Nuclear Science and Technology

- Applied Materials Science and Engineering
- Chemical Engineering
- Systems Engineering and Integration
- Large Scale User Facilities/Advanced Instrumentation

Pacific Northwest National Laboratory

Established in 1965, Pacific Northwest National Laboratory is managed by Battelle Memorial Institute and stewarded by the Office of Science.



	FY04	FY05	FY06	FY07	FY08	FY09	FY10	FY11	FY12	FY13	FY14
$M (2014)	357.5	420.3	405.1	410.4	563.5	566.6	632.0	546.7	551.5	644.4	582.8
% of DOE Lab Budget	3.0%	3.6%	3.6%	3.8%	5.0%	4.4%	5.3%	4.5%	4.6%	5.7%	5.0%

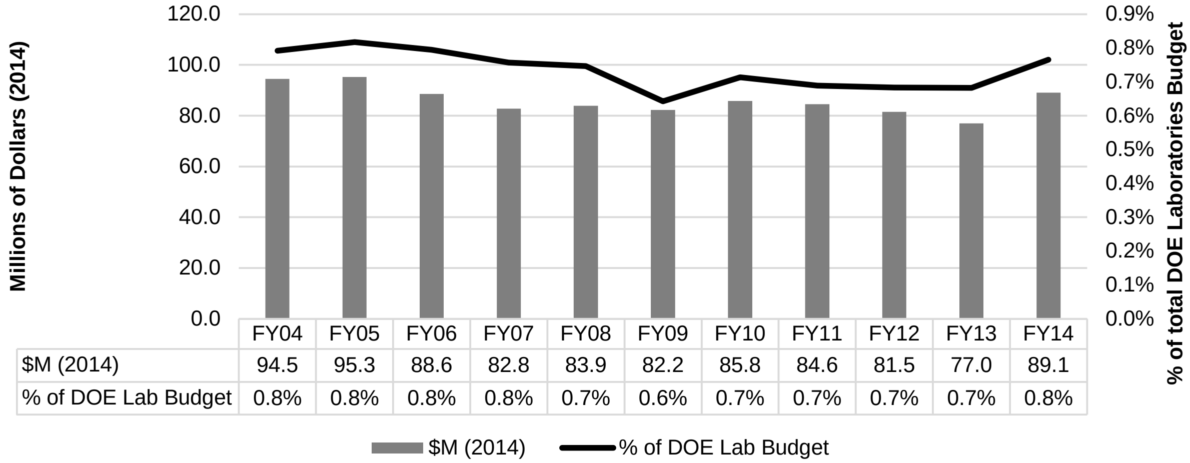
Figure D-12. Pacific Northwest National Laboratory Total Spending and Budget as Percentage of DOE National Laboratories Budget, FY2004-FY2014

Core Capabilities

- Chemical and Molecular Science
- Climate Change Science
- Biological Systems Science
- Environmental Subsurface Science
- Advanced Computer Science, Visualization, and Data
- Applied Nuclear Science and Technology
- Applied Materials Science and Engineering
- Chemical Engineering
- Systems Engineering and Integration
- Large Scale User Facilities / Advanced Instrumentation

Princeton Plasma Physics Laboratory

Established in 1951, Princeton Plasma Physics Laboratory is managed by Princeton University and stewarded by the Office of Science.



	FY04	FY05	FY06	FY07	FY08	FY09	FY10	FY11	FY12	FY13	FY14
$M (2014)	94.5	95.3	88.6	82.8	83.9	82.2	85.8	84.6	81.5	77.0	89.1
% of DOE Lab Budget	0.8%	0.8%	0.8%	0.8%	0.7%	0.6%	0.7%	0.7%	0.7%	0.7%	0.8%

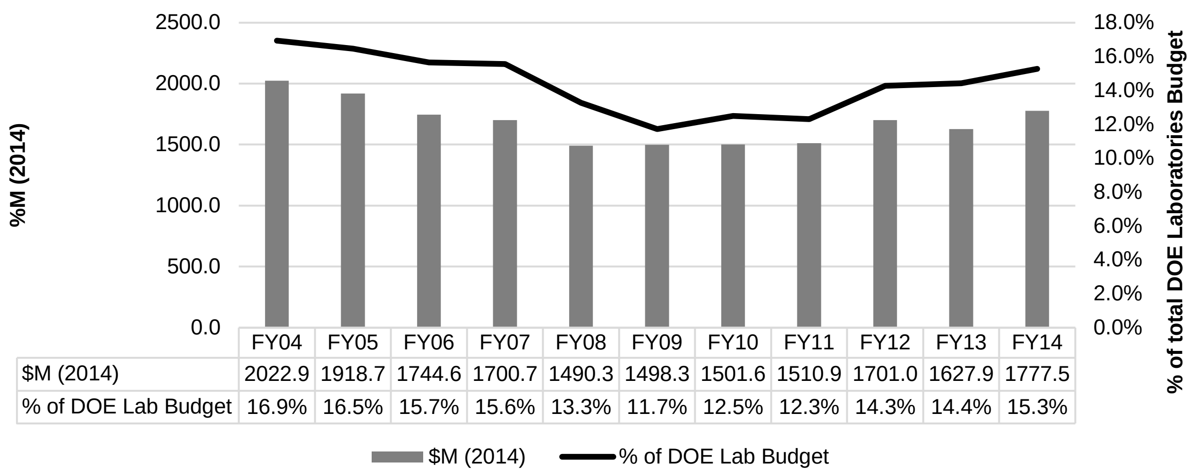
Figure D-13. Princeton Plasma Physics National Laboratory Total Spending and Budget as Percentage of DOE National Laboratories Budget, FY2004-FY2014

Core Capabilities

- Plasma and Fusion Energy Sciences
- Large Scale User Facilities / Advanced Instrumentation

Sandia National Laboratory

Established in 1949, Sandia National Laboratory is managed by Sandia Corporation and stewarded by the National Nuclear Security Administration.



	FY04	FY05	FY06	FY07	FY08	FY09	FY10	FY11	FY12	FY13	FY14
$M (2014)	2022.9	1918.7	1744.6	1700.7	1490.3	1498.3	1501.6	1510.9	1701.0	1627.9	1777.5
% of DOE Lab Budget	16.9%	16.5%	15.7%	15.6%	13.3%	11.7%	12.5%	12.3%	14.3%	14.4%	15.3%

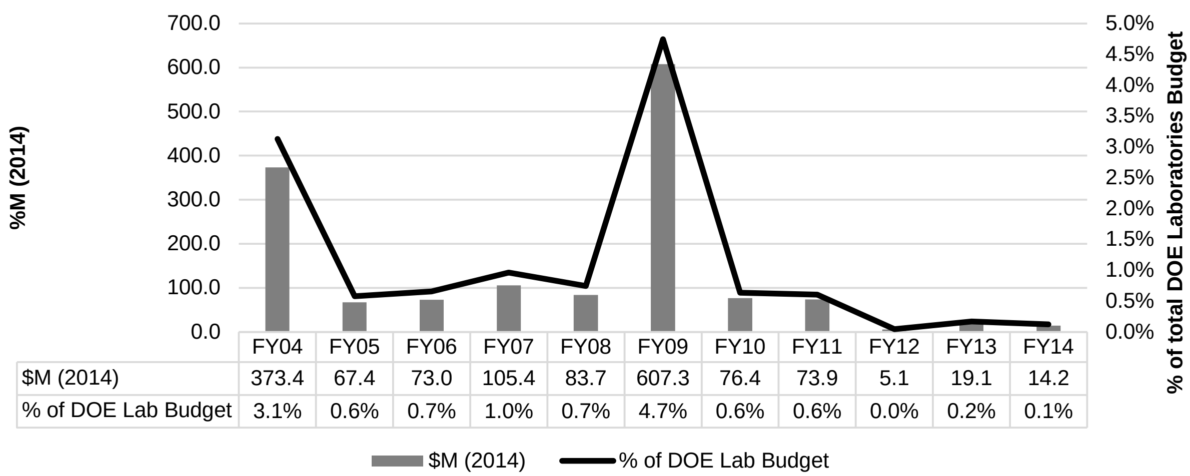
Figure D-14 Sandia National Laboratory Total Spending and Budget as Percentage of DOE National Laboratories Budget, FY2004-FY2014

Core Capabilities

- High Reliability Engineering
- Sensors and Sensor Systems
- Microsystems
- Natural and Engineered Materials
- Safety, Risk and Vulnerability Analysis
- Cyber Technology
- Reverse Engineering
- Modeling and Simulation
- Pathfinders

Savannah River National Laboratory

Established in 1951, Savannah River National Laboratory is managed by Savannah River Nuclear Solutions, LLC and stewarded by the Office of Environmental Management.



	FY04	FY05	FY06	FY07	FY08	FY09	FY10	FY11	FY12	FY13	FY14
$M (2014)	373.4	67.4	73.0	105.4	83.7	607.3	76.4	73.9	5.1	19.1	14.2
% of DOE Lab Budget	3.1%	0.6%	0.7%	1.0%	0.7%	4.7%	0.6%	0.6%	0.0%	0.2%	0.1%

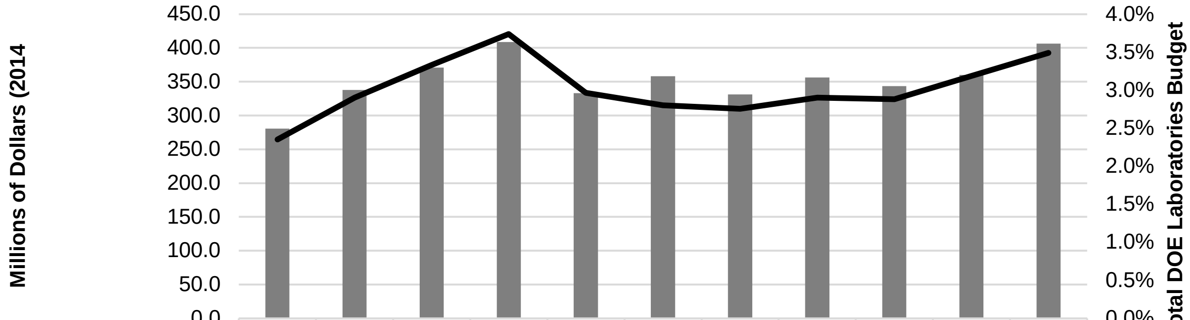
Figure D-15. Savannah River National Laboratory Total Spending and Budget as Percentage of DOE National Laboratories Budget, FY2004-FY2014

Core Capabilities

- Environmental Remediation and Risk Reduction
- Nuclear Materials Processing and Disposition
- Nuclear Detection, Characterization and Assessments
- Gas Processing, Storage and Transfer Systems

SLAC National Accelerator Laboratory

Established in 1962, SLAC National Accelerator Laboratory is managed by Stanford University and is stewarded by the Office of Science.



	FY04	FY05	FY06	FY07	FY08	FY09	FY10	FY11	FY12	FY13	FY14
$M (2014)	280.6	338.0	371.0	408.6	332.9	358.2	331.4	356.3	343.5	359.8	406.4
% of DOE Lab Budget	2.4%	2.9%	3.3%	3.7%	3.0%	2.8%	2.8%	2.9%	2.9%	3.2%	3.5%

$M (2014) — % of DOE Lab Budget

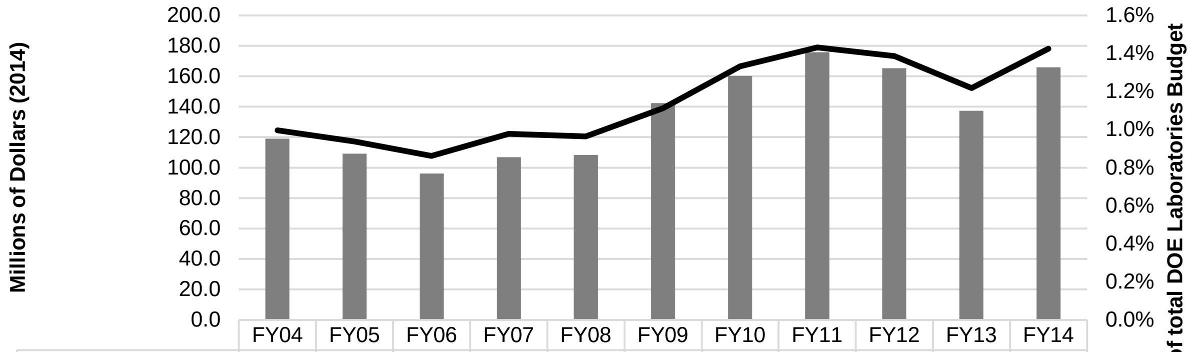
Figure D-16. SLAC National Accelerator Laboratory Total Spending and Budget as Percentage of DOE National Laboratories Budget, FY2004-FY2014

Core Capabilities

- Particle Physics
- Accelerator Science and Technology
- Condensed Matter Physics and Materials Science
- Chemical and Molecular Science
- Large Scale User Facilities / Advanced Instrumentation

Thomas Jefferson National Accelerator Facility

Established in 1984, Thomas Jefferson National Accelerator Facility is managed by Jefferson Science Associates, LLC and stewarded by the Office of Science.



	FY04	FY05	FY06	FY07	FY08	FY09	FY10	FY11	FY12	FY13	FY14
$M (2014)	119.0	109.2	96.1	106.9	108.3	142.3	160.3	175.7	165.3	137.3	165.9
% of DOE Lab Budget	1.0%	0.9%	0.9%	1.0%	1.0%	1.1%	1.3%	1.4%	1.4%	1.2%	1.4%

Figure D-17. Thomas Jefferson National Accelerator Facility Total Spending and Budget as Percentage of DOE National Laboratories Budget, FY2004-FY2014

Core Capabilities

- Nuclear Physics
- Accelerator Science and Technology
- Applied Nuclear Science and Technology
- Large Scale User Facilities / Advanced Instrumentation

Appendix E. Organizations Represented in Interviews

Department of Energy (DOE)

- Advanced Research Projects Agency-Energy
- National Nuclear Security Administration
- Office of Environmental Management
- Office of Fossil Energy
- Office of Inspector General
- Office of Independent Enterprise Assessments
- Office of Nuclear Energy
- Office of the Secretary
- Office of Science
- Office of the Under Secretary for Management and Performance
- Office of the Under Secretary for Science and Energy

Laboratory and M&O Contractor Personnel

- Argonne National Laboratory
- Battelle Memorial Institute
- Bechtel Corporation
- Brookhaven Science Associates/Stony Brook University
- Fermi National Laboratory
- Idaho National Laboratory
- Lawrence Berkeley National Laboratory
- Lawrence Livermore National Laboratory
- Lockheed Martin Corporation
- Los Alamos National Laboratory
- National Renewable Energy Laboratory
- Savannah River National Laboratory
- SLAC National Accelerator Laboratory
- University of Chicago

Other Federal Agencies

- Central Intelligence Agency
- Department of Defense
- Department of Homeland Security
- Department of State
- Defense Threat Reduction Agency
- Federal Bureau of Investigation
- Government Accountability Office
- Intelligence Advanced Research Projects Activity
- National Aeronautics and Space Administration
- National Research Council
- Naval Facilities Engineering Command
- Navy Strategic Systems Programs

- Nuclear Regulatory Commission
- National Science Foundation
- Office of Management and Budget
- Office of Science and Technology Policy
- Office of the Director of National Intelligence
- Office of the Secretary of Defense (OSD)-Acquisition, Technology, and Logistics (AT&L), Installations & Environment
- OSD-AT&L, Research & Engineering
- OSD-Operational Energy Plans and Programs
- United States European Command
- United States House of Representatives, Subcommittee on Energy and Water Development
- United States Pacific Command
- United States Senate, Subcommittee on Energy and Water Development
- United States Southern Command

Other Stakeholders

- AKHAN Technologies, Inc.
- American Association for the Advancement of Science
- BASF Corporation
- Brookings Institution
- Decker, Garman, Sullivan & Associates LLC
- Dow Chemical Company
- Eli Lilly and Company
- Energy Efficient Buildings Hub, Philadelphia Navy Yard
- General Atomics
- Harvard Kennedy School
- Henry L. Stimson Center
- Howard Hughes Medical Institute
- Institute for Molecular Engineering, University of Chicago
- Institute of Applied Research, University of Illinois at Urbana-Champaign
- Johnson Controls Power Solutions
- Michigan State University
- National Academy of Public Administration
- Natural Resources Defense Council
- Nuclear Watch New Mexico
- Project on Government Oversight
- The Heritage Foundation
- The Information Technology & Innovation Foundation
- Tri-Valley Communities Against a Radioactive Environment
- United States Council for Automotive Research
- University of Texas, Austin

Appendix F.
User Facilities by Laboratory

The following user facilities have been self-identified by individual laboratories. The Office of Science in DOE provides an official definition of user facilities in an official memorandum,[139] as well as a list of some user facilities at SC laboratories.[140] DOE's official list includes some but not all of the user facilities listed in Table F-1.

Table F-1. User Facilities

National Laboratory	User Facility
Global network	Atmospheric Radiation Measurement (ARM) Climate Research Facility - Argonne, Brookhaven, Lawrence Berkeley, Lawrence Livermore, Los Alamos, NREL, Oak Ridge, Pacific Northwest, and Sandia participate (1,000 users)
Argonne	Advanced Photon Source (APS), (4,500 users)
http://science.energy.gov/~/media/_/pdf/user-facilities/Office_of_Science_User_Facility_Definition_Memo.pdf	Argonne Leadership Computing Facility (ALCF), (1,000 users) Argonne Tandem Linac Accelerator System (ATLAS), (400 users) Center for Nanoscale Materials (CNM), (400 users) Transportation Research Analysis Computing Center (TRACC) funded by Department of Transportation
Brookhaven	Accelerator Test Facility (ATF)
http:/www.bnl.gov/guv/facilities.asp	Center for Functional Nanomaterials (CFN), (400 users) Computational Science Center (CSC) NASA Space Radiation Laboratory (NSRL) National Synchrotron Light Source II (NSLS-II), (over 250 users)* Relativistic Heavy Ion Collider (RHIC), (1,200 users) Tandem Van de Graaf Facility (TANDEM)
Fermilab	Proton Accelerator Complex (1,400 users)
Idaho	Advanced Test Reactor (ATR)
https://inlportal.inl.gov/portal/server.pt/community/renewable_energy_home/419/user_facility https://inlportal.inl.gov/portal/server.pt	Biomass Feedstock National User Facility (BFNUF)† Wireless National User Facility

[139]Patricia Dehmer, "Definition of a User Facility"

[140]The list, last updated in October 2014, is available at http://science.energy.gov/~/media/_/pdf/user-facilities/Office_of_Science_User_Facilities_FY_2015.pdf.

National Laboratory	User Facility
?open=514&objID=1555&mode=2&featurestory=DA_605130	
Lawrence Berkeley http://www2.lbl.gov/LBL-Programs/nuf.html	Advanced Light Source (ALS), (1,800 users) Energy Sciences Network (ESNet), (27,000 users) Joint Genome Institute (JGI), (1,000 users) The Molecular Foundry (400 users) National Center for Electron Microscopy (NCEM) National Energy Research Scientific Computing Center (NERSC), (5,000 users)
Lawrence Livermore‡	Livermore program-focused facilities • Contained Firing Facility (CFF) • High Explosives Applications Facility (HEAF) • High Performance Computing (HPC), including Sequoia • Joint Actinide Shock Physics Experimental Research (JASPER) • National Ignition Facility (NIF) • Livermore Facilities accessed by External R&D Community • B194 Accelerator Facility • Center for Accelerator Mass Spectrometry (CAMS) • Jupiter Laser Facility (JLF) • National Atmospheric Release Advisory Center (NARAC) • National Ignition Facility (NIF)
Los Alamos http://www.lanl.gov/collaboration/user-facilities/index.php	Center for Integrated Nanotechnologies (CINT), (400 users with Sandia National Laboratories) Lujan Neutron Scattering Center (LANSCE), (150 users) National High Magnetic Field Laboratory (NHMFL)
NREL§ http://www.nrel.gov/research_facilities/user_facilities.html	Energy Systems Integration Facility (ESIF) Thermochemical Users Facility
Oak Ridge http://www.ornl.gov/user-facilities	Building Technologies Research & Integration Center (BTRIC) Center for Nanophase Materials Sciences (CNMS), (400 users) Center for Structural Molecular Biology (CSMB) Carbon Fiber Technology Facility (CFTF) High Flux Isotope Reactor (HFIR), (400 users) Manufacturing Demonstration Facility (MDF) National Transportation Research Center (NTRC) Oak Ridge Leadership Computing Facility (OLCF), (1,300 users) Spallation Neutron Source (SNS), (750 users)
Pacific Northwest http://www.pnnl.gov/about/facilities.asp	Environmental Molecular Sciences Laboratory (EMSL), (750 users)
PPPL http://nstx-u.pppl.gov/	National Spherical Torus Experiment (NSTX), (165 users)
Sandia	Center for Integrated Nanotechnologies (CINT), (400 users

National Laboratory	User Facility
http://www.sandia.gov/research/facilities/technology_deployment_centers/	with Los Alamos National Laboratory) • Technology Deployment Centers • Advanced Power Sources Laboratory • Combustion Research Facility • Design, Evaluation, and Test Technology Facility • Distributed Energy Technology Laboratory • Engineering Sciences Experimental Facilities (ESEF) • Explosive Components Facility • Explosive Technology Group • Geomechanics Laboratory • Ion Beam Laboratory • Materials Science and Engineering Center • Mechanical Test Evaluation Facility • Microsystems and Engineering Sciences Applications • National Solar Thermal Test Facility (NSTTF) • Nuclear Energy Safety Technologies (NEST) • Nuclear Facilities Resource Center (NUFAC) • Photovoltaic Laboratories • Plasma Materials Test Facility • Pulsed-Power and Systems Validation Facility • Primary Standards Laboratory • Radiation Detection Materials Characterization Laboratory • Shock Thermodynamic Applied Research Facility (STAR) • Weapon and Force Protection Center
SLAC https://www6.slac.stanford.edu/facilities https://news.slac.stanford.edu/tags/programs-facilities/lightsources/lcls-ii	Facility for Advanced Acceleratory Experimental Tests (FACET), (48 users) Linac Coherent Light Source (LCLS), (500 users) Linac Coherent Light Source II (LCLS-II) Stanford Synchrotron Radiation Light Source (SSRL), (1,700 users)
Thomas Jefferson http://education.jlab.org/pol/user-facility.html	Continuous Electron Beam Accelerator Facility (CEBAF), (1,245 users)

* NSLS served over 2,000 users, and the upgrade is expected to serve a similarly sized user community.

† The BFNUF was designated a user facility in the summer of 2013 for “scientific and technical investigation of biomass feedstock,” http://www.innovation-america.org/you-can-call-it-%E2%80%9Cbfnuf%E2%80%9D.

‡ Information was supplied to the Commission by Lawrence Livermore. Not listed are Lawrence Livermore’s facilities that are “run for the benefit of several Federal agencies.” Facilities like this include the Forensics Sciences Center, the Biodefense Knowledge Center, and the Counterproliferation Analysis and Planning System. This is not an exhaustive list of LLNL’s capabilities.

§ NREL has 15 testing facilities in addition to ESIF that allow industry and other organizations to collaborate with the laboratory. The other facilities are not considered “user,” but they have similar properties to user facility collaborations.

Appendix G.
LDRD Supplementary Information

Laboratory directed research and development (LDRD) funding complies with statutory requirements set by Congress and DOE. DOE Order 413.2B defines the objectives and provides the regulatory limits on uses of LDRD funding, based on congressional legislation. Order 413.2B states that LDRD funds will not be used to:

1. substitute for or increase funding for any tasks for which a specific limitation has been established by Congress or the Department or for any specific tasks that are funded by DOE/NNSA or other users of the laboratory;
2. fund projects that will require the addition of non-LDRD funds to accomplish the technical goals of the LDRD project, except as provided by legislation;
3. fund construction design beyond the preliminary phase (e.g., conceptual design, Title I design work, or any similar or more advanced design effort) or fund line-item construction projects, in whole or in part; or
4. fund general purpose capital expenditures with the exception of acquisition of general purpose equipment that is clearly required for the project and is not otherwise readily available from laboratory inventory.

The percentage cap on LDRD is determined by Congress. The Consolidated Appropriations Act of FY 2014, Section 309 establishes the percentage cap on funding at 6%. Previously the established cap for LDRD funding was 8%, as established in the FY 2006 Energy and Water Development Appropriations Act, Public Law 109-103, Section 311. This change has not yet been updated in DOE Order 413.2B.The House Energy and Water Appropriations Bill of FY 2015, Sec. 314 also establishes that no individual program, project, or activity funded through the Energy and Water Development appropriations Act may be charged greater than the 6% cap.

Table G-1. Reported LDRD at National Laboratories spending in % of total expenditures, FY2004-FY2014

	FY04	FY05	FY06	FY07	FY08	FY09	FY10	FY11	FY12	FY13	FY14
NNSA											
Lawrence Livermore	4.92%	4.91%	6.61%	6.30%	5.95%	5.76%	5.72%	6.05%	5.58%	5.41%	1.96%
Los Alamos	5.49%	5.41%	6.20%	6.81%	6.47%	6.31%	5.81%	6.27%	6.93%	7.06%	1.89%
Sandia	5.35%	5.38%	6.34%	6.67%	6.76%	6.85%	6.76%	6.55%	6.69%	6.48%	3.29%
Office of Science											
Ames										0.61%	5.54%
Argonne	4.58%	4.35%	4.62%	4.53%	4.95%	4.70%	4.53%	4.18%	4.11%	3.65%	3.96%
Brookhaven	1.63%	1.86%	2.64%	2.27%	2.52%	2.44%	2.33%	2.49%	1.97%	1.43%	3.87%
Lawrence Berkeley	2.49%	2.82%	3.84%	3.22%	3.19%	3.23%	3.00%	2.85%	2.83%	3%	2.95%
Oak Ridge	2.05%	1.92%	2.75%	2.58%	2.42%	2.64%	2.41%	2.31%	2.36%	2.57%	1.55%
Pacific Northwest	3.59%	3.01%	4.17%	3.77%	3.56%	3.36%	4.09%	4.39%	4.48%	4.51%	0.19%
Princeton Plasma Physics				1.14%	1.35%	1.36%	2.12%	2.76%	2.52%	2.22%	0.06%
SLAC						0.79%	1.29%	1.28%	1.32%	1.09%	2.05%
Other (NE, EERE, EM)											
Idaho	1.48%	3.13%	3.08%	3.06%	3.05%	2.86%	2.70%	3.18%	3.17%	2.58%	3%
NREL				1.87%	2.17%	2.03%	2.44%	2.53%	2.62%	3.14%	1.70%
Savannah				1.67%	1.94%	3.04%	3.01%	3.66%	3.70%	3.11%	2.89%

Data from DOE Fiscal Year 2004-2014 LDRD Reports to Congress.

Table G-2. Reported LDRD at National Laboratories spending in millions of dollars ($M), FY2004-FY2014, inflation unadjusted

	FY04	FY05	FY06	FY07	FY08	FY09	FY10	FY11	FY12	FY13	FY14
NNSA											
Lawrence Livermore	69.8	71	93.9	92.7	91.5	85.1	88.7	96.6	91.8	83.3	78.2
Los Alamos	102.1	106	125.4	130.3	124.7	125.8	126.4	138.3	142.1	142.1	118.5
Sandia	104	110.8	131.7	143.7	149.2	148	152.7	160.6	162.3	165.1	151.3
Office of Science											
Ames										0.4	1
Argonne	24.9	22.2	22.9	24.1	27.9	26.6	28.5	29.6	28.9	28.4	29.2
Brookhaven	7.2	8.4	11.1	10.2	12	11.7	11.3	12.2	10.1	7.6	9.6
Fermilab											0.2
Lawrence Berkeley	12	13.6	18.6	16.2	18.3	19.6	20.6	20.4	20	22.9	23.6
Oak Ridge	15.3	16.7	24.2	26.4	28.9	31.4	32.2	32.1	32.7	35.3	36.3
Pacific Northwest	18.3	19.2	27.6	25.5	27.4	29.4	35.8	40.3	41.4	40.5	38.9
Princeton Plasma Physics				0.9	0.8	1.1	1.8	2.4	2.2	2	2
SLAC						1.8	3.3	3.6	4.1	3.4	4.4
Thomas Jefferson											0.2
Other (NE, EERE, EM)											
Idaho	11.8	16.8	21.1	22.6	24.3	24.9	28.6	30.8	28.4	21.7	17
NREL				3.7	5.2	5.8	7.3	8.7	9.2	10.3	10.3
Savannah River				2.3	2.7	4.6	4	5.6	5.7	5.6	6.2

Source: Data from DOE Fiscal Year 2004-2014 LDRD Reports to Congress. Data not adjusted for inflation.

Table G-3. LDRD-Supported Post-Doctoral Researchers in Percentage of Individual Laboratory Post-Doctoral Researcher Populations, FY 2004–FY 2013

	FY04	FY05	FY06	FY07	FY08	FY09	FY10	FY11	FY12	FY13
NNSA										
Lawrence Livermore	85.0%	85.0%	82.0%	79.0%	75.0%	82.0%	48.9%	44.0%	44.7%	45.7%
Los Alamos	62.0%	61.0%	59.0%	73.0%	62.0%	64.0%	57.3%	56.6%	58.4%	57.1%
Sandia	55.0%	67.0%	52.0%	50.0%	55.0%	77.0%	49.1%	42.5%	62.8%	44.9%
Office of Science										
Ames										1.60%
Argonne	26.0%	17.0%	18.0%	34.0%	47.0%	26.0%	28.9%	26.9%	28.9%	24.8%
Brookhaven	39.0%	30.0%	30.0%	14.0%	23.0%	24.0%	16.2%	18.5%	18.6%	15.7%
Lawrence Berkeley	19.0%	22.0%	23.0%	20.0%	17.0%	15.0%	14.2%	12.5%	10.6%	12.5%
Oak Ridge	32.0%	20.0%	31.0%	24.0%	22.0%	21.0%	16.9%	13.2%	14.2%	11.9%
Pacific Northwest	28.0%	35.0%	30.0%	32.0%	35.0%	29.0%	19.4%	22.2%	28.4%	25.9%
Princeton Plasma Physics				0.0%	50.0%	20.0%	16.7%	11.5%	10.0%	9.5%
SLAC						4.0%	4.0%	10.4%	14.8%	8.8%
Other (NE, EERE, EM)										
NREL				7.0%	10.0%	10.0%	11.7%	25.0%	17.9%	29.1%
Savannah River				39.0%	17.0%	31.0%	47.1%	64.3%	50.0%	63.6%
Idaho	11.0%	44.0%	83.0%	70.0%	48.0%	55.0%	52.6%	73.9%	42.1%	46.2%

Source: Data provided by John LaBarge and Russell Ames, DOE Office of Science. The Commission will update FY2014 data as it is made available.

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Abbreviations

AAAS	American Association for the Advancement
ALCF	Argonne Leadership Computing Facility
ALS	Advanced Light Source
APS	Advanced Photon Source
APS-U	Advanced Photon Source Upgrade
ASC	Advanced Simulation Computing
ASCR	Advanced Scientific Computing Research
AT&L	Acquisition, Technology and Logistics
B	billion ($)
BESAC	Basic Energy Sciences Advisory Committee
BRC	Bioenergy Research Center
CERN	European Organization for Nuclear Research
CFN	Center for Functional Nanomaterials
CINT	Center for Integrated Nanotechnologies
CNM	Center for Nanoscale Materials
CNMS	Center for Nanophase Materials Science
CORAL	Collaboration of Oak Ridge, Argonne, and Livermore
COV	Community of Visitors
CRADA	Cooperative Research and Development Agreements
CRS	Congressional Research Service
CUBE	Consolidated Utility Base Energy
DHHS	Department of Health and Human Services
DHS	Department of Homeland Security
DOD	Department of Defense
DOE	Department of Energy
EERE	Office of Energy Efficiency and Renewable Energy
EFRC	Energy Frontier Research Center
EM	Office of Environmental Management
ESIF	Energy Systems Integration Facility
ESIF	Energy Systems Integration Facility
FBI	Federal Bureau of Investigation
FE	Office of Fossil Energy
FFRDC	Federally Funded Research and Development Center
FRIB	Facility for Rare Isotope Beams
FTE	full-time equivalent
FY	fiscal year
GAO	Government Accountability Office/General Accounting Office
GDP	gross domestic product
GOGO	government-owned, government-operated

HEPAP	High Energy Physics Advisory Panel
HPC	high performance computing
IC	Intelligence Community
JBEI	Joint Bioenergy Institute
LCLS	Linac Coherent Light Source
LCLS-II	Linac Coherent Light Source II
LDRD	laboratory directed research and development
M	million ($)
M&O	management and operations
MEC	Mission Executive Council
NARAC	National Atmospheric Release Advisory Center
NASA	National Aeronautics and Space Administration
NAPA	National Academy for Public Administration
NDAA	National Defense Authorization Act
NE	Office of Nuclear Energy
NERSC	National Energy Research Scientific Computing Center
NETL	National Energy Technology Laboratory
NGLS	Next Generation Light Source
NIF	National Ignition Facility
NIH	National Institutes of Health
NISAC	National Infrastructure Simulation and Analysis Center
NIST	National Institute of Standards and Technology
NNI	National Nanotechnology Initiative
NNSA	National Nuclear Security Administration
NRC	National Research Council or Nuclear Regulatory Commission
NREL	National Renewable Energy Laboratory
NSF	National Science Foundation
NSLS	National Synchrotron Light Source
NSLS-II	National Synchrotron Light Source II
NSRC	Nanoscale Research Center
NUFO	National User Facility Organization
NVAC	National Visualization and Analytics Center
ODNI	Office of the Director of National Intelligence
OECD	Organisation for Economic Cooperation and Development
OIG	Office of Inspector General
OLCF	Oak Ridge Leadership Computing Facility
OMB	Office of Management and Budget
OSD	Office of the Secretary of Defense
OSTP	Office of Science and Technology Policy
P-5	Particle Physics Project Prioritization Panel
PEMP	Performance Evaluation and Measurement Plan
PFIAB	President’s Foreign Intelligence Advisory Board
R&D	research and development
RFI	Request for Information

S&T	science and technology
SC	Office of Science
SEAB	Secretary of Energy Advisory Board
SLAC	SLAC National Accelerator Laboratory
SSMP	Stockpile Stewardship and Management Plan
SSRL	Stanford Synchrotron Radiation Lightsource
STPI	Science and Technology Policy Institute
USCAR	United States Council for Automotive Research
WFO	Work for Others