Testimony of
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U.S. Committee on Energy and Natural Resources

"Hearing to Examine the Leading Role of the DOE and Energy Innovation in American Economic Competitiveness"

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Mr. Chairman, thank you for inviting me to testify on how our national laboratories contribute to scientific innovation and the scientific tools needed to maintain our competitiveness.

I would first like to commend the many members of the Senate who recognize the critical role that innovation, driven by federal investment in research and technology development, plays in competing with other nations and ensuring US leadership in key technology areas. I have spent most of my career within the Department of Energy National Laboratories but also spent time as a faculty member at a public research university, in industry and at a European National Laboratory. This gives me a great appreciation for the technological harnessing that only our federal government can foster.

Since its founding in the Manhattan Project, the Department of Energy (DOE) national laboratory system has delivered scientific advances and technology solutions for the nation, while balancing the need for open, collaborative science with the imperatives of national security, economic and energy security, and technological superiority. The innovation from the Manhattan Project and Cold War era propelled the U.S. to be the world leader in nearly every technological area for several decades.

Innovation in this era led to such things as nuclear power, satellite communications, medical imaging, supercomputing, advances in energy efficiency, and the human genome project. The U.S. dominated for decades in these fields, but our competitors were not sitting still either. Today technology innovation remains the key to economic growth ***and*** national security.

Although our competitors are making strides to catch the U.S, our leadership is still clear in a number of areas. The US continues to lead the world in pushing the boundaries in space, thanks to both government and private investments. Landing of the Curiosity Rover on Mars and the advent of Space X's reusable rockets reaffirms that this country is a world leader in space and can form effective partnerships with private industry simultaneously. While this is a clear example of US leadership, there are other examples like semiconductor and microelectronics fabrication and packaging, computer hardware and software design, autonomous vehicle development, telecommunications, and surveillance technology where it's not so clear. In the postwar/cold war era when the National Labs grew into prominence the U.S.

had a larger economy and larger research enterprise than the rest of the world combined. In the 21st century, while we are still a major player, we are no longer a uniquely dominant force. Innovation is emerging globally and we can no longer take our leadership for granted.

While the U.S. has invested significant sums into high performance computing, China has surpassed this and may beat the U.S. to deploying an Exascale computing platform. The same is playing out in artificial intelligence and 5G networks. In the national security realm, China and Russia are more rapidly modernizing their nuclear stockpiles and have newer weapons research and validation tools that are similar and possibly more powerful than U.S. facilities. China is now the world's largest electricity producer, and is building resiliency into the modernization of its power grid, including application of AI, and potentially quantum technologies in the future.

Our global competitors are investing significant funds into their scientific and national security research institutions. In fact, they are modeling these institutions off of the U.S. national lab system. President Xi Jinping, for example, stated that the success of China's "Two Bomb, One Satellite program" is dependent upon the integration of leading scientists, academics, and leading innovation system construction. He stated, "A number of national laboratories should be established, and the existing state key laboratories should be reorganized to form a laboratory system in China." It is no accident that the Chinese believe that investing in basic scientific research and the creation of a Chinese national lab system will lead to S&T innovation breakthroughs.

The blueprint for Chinese comprehensive national laboratories is explicitly modeled on our system – imitation may be a form of flattery but it is no time for complacency. While we have a multi decade head start it means that much of the research infrastructure in the U.S. is aging. Our institutions and people have been further challenged by the current pandemic and it has been gratifying to seeing the response to this crisis. If we are to compete for the leadership role in the future, the U.S. must both revitalize its physical and human capital infrastructure and have a coordinated approach between the many agencies, institutions, and private industry that are currently working in key emerging technology areas. This U.S. innovation ecosystem is noteworthy for the complementary roles that national labs, universities, and industry play.

The DOE and its laboratories strike a delicate balance between open science and S&T in the national interest. The laboratories build and maintain unique, large-scale and world-leading research tools that are utilized broadly by university and industrial researchers like supercomputing facilities and an array of light and neutron source user facilities. They also serve as an irreplaceable on-the-job training ground for students, faculty, and early career scientists through the many different student programs supported by DOE. The alumni of these programs populate laboratory, industry, and university workforces. They also go on to create many different startups in many different technological areas.

The Labs also assemble and nurture multi-disciplinary teams of scientific experts to meet federal needs and address national priorities by attacking R&D challenges of scale and translating those advances to practice. Consortia supported by the Department are accelerating the development of modern approaches to grid management and the hydrogen economy. The ability of the labs to work together rapidly to solve problems was further evidenced most recently by the research and development efforts of the National Virtual Biotechnology Laboratory (NVBL), established in response to the COVID-19 Pandemic. The NVBL used laboratory capabilities to support rapid development of anti-viral agents and vaccines, supported many different organizations with modeling disease spread and providing real-time tools for decision making and risk assessment, aided in increasing testing throughput, and used advanced manufacturing to address supply chain bottlenecks.

Universities educate and train scientists, engineers and teachers, and generate new ideas by performing cutting-edge research. They are supported by the NSF, which is the only federal agency charged with the promotion of scientific progress across all science and engineering disciplines; the research funded through its rigorous peer review process is vital to the public interest and has led to transformative discoveries that have reshaped our world. They provide a neutral and fertile ground for scientific collaboration and integrate key issues of policy and society into research and development.

The role of industry is critical to moving basic ideas and early and mid-stage applied research to products that are ready for the marketplace. Industry delivers these technological advances to the marketplace and to society by making strategic, early investments in new technology. They hire scientific and engineering talent produced by universities and trained at national laboratories to meet their workforce needs and remain globally competitive. Industry drives commerce and innovation through in-house research and by harnessing scientific advances and technology developed at universities and national laboratories. They also utilize and many times partner with the national laboratories to take advantage of the unique research tools of the laboratories to move technologies to the marketplace.

National laboratories occupy a unique position in this ecosystem, synthesizing and applying science and engineering to problems of national interest, often working in areas where there is the potential of national or economic security ramifications to science and technology. From our founding as part of the Manhattan project we have been focused on the full breadth of the innovation pipeline. At Los Alamos we like to say we always start with the science but we don't stop there. Our responsibility starts with the fundamental nuclear, materials, and chemical sciences that underpin the stockpile through the engineering disciplines that realize those physics designs in real weapons system and even to the manufacturing of warheads that ultimately are deployed by the Navy and Air Force. That same mission driven focus on seeing our science engineering deployed extends to other areas such as energy and pandemic response.

In order to continue turning out world leading S&T, I recommend investments across this ecosystem. The need to engage the full breadth of our science ecosystem has also been highlighted in several recent reports, including those from PCAST and the Council on Competitiveness. Investment is needed in the Department of Energy and the national laboratories, in coordination and collaboration with the National Science Foundation (NSF), to advance key technology areas and to fund increased access to world-leading user facilities utilized by NSF scientists to advance scientific discovery and technology development. Providing greater resources across the innovation ecosystem is the best way to achieve the Senate's goals of bolstering our competitiveness with countries like China. Our distributed, multi-agency, multi-stakeholder approach to science and technology has served the nation well throughout its history. We bring diverse viewpoints, wide ranging capability, and individual creativity and ingenuity to science and technology in a way no other country can match.

Three illustrative areas where integrated collaboration is needed:

- In quantum computing and information systems, the National Laboratories are leading five National Quantum Information Science Research Hubs – each with diverse members that include American industry, universities, and National Laboratories – funded by the Department of Energy, thanks to bipartisan congressional support for the National Quantum Initiative and subsequent appropriations. These centers are part of a coordinated, multi-agency effort with the NSF and National Institute for Standards and Technology (NIST), and serve as an excellent example of a complementary, multi-agency approach.
- In high performance computing, the National Laboratories operate two out of the top three of the world's fastest supercomputers with more coming online later this year and early next through the Exascale Computing Initiative. And by nature of their design, these exascale systems will also represent the most powerful artificial intelligence machines in the world. In addition to the supercomputers, the National Laboratories have some of the world's leading experts in computer science and advanced mathematics, which is crucial to leveraging each new generation of bigger and better computing capabilities through advanced software development. The pipeline of these experts is fueled by complementary investments in the NSF and the researchers those investments produce. This is also a key area where DOE and the National Labs have long maintained the delicate balance between the need for open science and imperative for national security as stewards of the nation's nuclear deterrent, as evidenced, e.g., by partnerships between DOE's Office of Science and NNSA.
- In advanced energy, industrial efficiency, and materials science, the Department of Energy – across nearly its entire portfolio – is the lead agency for the nation in driving innovation through research and development efforts at National Laboratories and universities in partnership with industry. Ideas generated through NSF investment at universities are proven out at DOE user facilities and translated to realization through National Lab-University-Industry consortia. DOE plays a key role in capability development and stewardship, especially at the National Labs; and in supporting robust public-private partnerships. Similarly, NSF user facilities (including the National High Magnetic Field Facility, a partnership between Florida State University, the University of Florida, and Los Alamos National Laboratory) enable forefront science in materials, energy and life sciences.

Significant investments in our nation's S&T ecosystem are needed if we are to remain competitive on the international stage. However, these investments should be made in an integrated manner that supports all the parts of the ecosystem, because the whole of this ecosystem is greater than the sum of its parts. And the parts are interdependent – universities, national laboratories and industry are all needed, and all need each other, for the ecosystem to thrive. America's innovation ecosystem is the envy of the world, which is why so many other nations are trying to copy our model. The grand scientific challenges of the 21st Century are so large they require full mobilization of the assets in our research enterprise, well-coordinated across agencies. We need to recognize the challenge of international competition but not shy away from cooperation with partners who share our values and commitment to transparent collaboration to the mutual benefit of all parties involved. America looks to Congress and the White House to ensure that the ecosystem remains healthy and vibrant.