COUNCIL ON STRATEGIC RISKS | THE NOLAN CENTER

BRIEFER

No. 20 | June 22, 2021

Key U.S. Initiatives for Addressing Biological Threats Part 2: The U.S. Department of Energy National Laboratories

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INTRODUCTION

The COVID-19 crisis has forcefully demonstrated the seriousness of the threat posed by natural and anthropogenic biological risks. Despite significant difficulties, it has also highlighted the incredible strides gained in modern biotechnology to address these risks, such as with the novel RNA-based vaccines developed to help halt the pandemic.[1] In this context, modern biological sciences are a key area of scientific competition with profound implications for the future of mankind and health of the planet.

Enter the U.S. Department of Energy (DOE). The DOE has a long history in developing and advancing basic science and technologies for national security and economic advancement. The department has unique capabilities and talent, including leading experts in the fundamental sciences, and cutting-edge tools and infrastructure that public and private partners can leverage to facilitate both discovery and innovation. Further, DOE's history and missions have made it a center of excellence in executing basic science and technology development at scale.

[1] Christine Parthemore, Anup Singh, and Andrew Weber, *Critical Steps in Preventing Future Pandemics: Early Lessons from the COVID-19 Crisis for Addressing Natural and Deliberate Biological Threats*. 2020.

The DOE has also mobilized its National Laboratories (the Labs) to respond to a number of significant national and international crises, including the 9/11 attacks, the Fukushima-Daiichi nuclear accident in Japan, and the Deepwater Horizon oil spill in the Gulf of Mexico.[2] Most recently, the DOE and the Labs have participated in the response to the ongoing COVID-19 pandemic, including genomics and structural biology of the virus, complex epidemiological modeling of disease spread, improved testing, and addressing supply bottlenecks for critical items such as masks, parts for ventilator systems, and consumables for testing kits.[3]

Despite these achievements, DOE's assets and accomplishments in the biological domain are not widely recognized. The Labs are the DOE's stewards for the nations's major scientific facilities such as x-ray light sources, neutron sources, supercomputers, cryo-electron microscope equipment, and other infrastructure that is critical for advancing biology and that is used by academia and industry (such as pharmaceutical companies) alike.[4] The Labs also have substantial genomic sequencing and analysis capabilities derived from the Human Genome Project which are now used primarily for the analysis of plants, microorganisms, and other components of environmental biology.[5]

DOE and the Labs face at least two challenges to the effective support for the Nation's biosecurity in the future. First, the Labs need to build the talent, laboratory infrastructure, and programmatic support necessary to lead in the current frontier of biology---a frontier now led by academia and private companies and geared toward the engineering of novel pathways, functions, and even whole organisms. Second, artificial limits and perceptions that prevent leveraging the unique capabilities and the expertise in science at scale of DOE and the Labs for biosecurity and biotechnology must be overcome. Other than for the collaboration with the National Institutes of Health for the Human Genome Project, the DOE and its programs generally have been steered away from DOE-supported work related to human biology under the premise that this is not a DOE mission. Biosecurity is now a whole-of-government mission that cannot be accomplished without the Labs.[6]

It is time to address these issues so DOE can function as a key component of national efforts to prevent future pandemics, deny deliberate biological threats of their potential for mass effect, maintain U.S. leadership in biotechnology, and apply the fruits of scientific competition and modern biological sciences toward the future of mankind and the health of the planet.

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[2] For examples, see Department of Energy - Lawrence Livermore National Laboratory, "A Brief History of CAMS,"; Department of Energy - Office of Nuclear Energy, "Fukushima: Looking Back, Looking Ahead," March 11, 2016; and Department of Energy, "Data from Deepwater Horizon," October 19, 2010.

[3] Department of Energy - Office of Science, "National Virtual Biotechnology Laboratory (NVBL)."

[4] Department of Energy, *The State of the DOE National Laboratories* (2020), 19 - 23.

[5] Department of Energy - Office of Science, "Genomics."

[6] Bipartisan Commission on Biodefense, *Biodefense in Crisis: Immediate Action Needed to Address National Vulnerabilities* (2021), 19 - 31.

To do so, the U.S. government should launch a strategic shift that positions the Labs to be at the forefront of research in engineering biology, with a goal of strengthening the nation's biosecurity while also leveraging the Labs' capabilities for the bioeconomy. Engineering biology is key to core energy and environmental missions of the DOE such as bio-derived fuels and U.S. competitiveness in the products and processes of the bioeconomy. Engineering biology is also a critical capability for national security that enables responses to naturally occurring and anthropogenic biothreats. Uniquely in the United States, the Labs are capable of basic and applied research, innovation and technology transfer, and participation in sensitive national security missions often requiring very specialized and restricted facilities. It is critical that the U.S. have first-rate talent and infrastructure within the federal system to participate in the new and profoundly important field of engineering biology, not least in order to prepare for and to respond to biological threats. The DOE Labs are the appropriate place for this capability.

A number of strategic and tactical policy and programmatic measures would support this shift. Specifically, the U.S. government should:

- Implement program and facility funding for engineering biology with a special focus on biosecurity to make the Labs leaders in this critical area of biotechnology and facilitate academic and private sector partnerships. This should include a focused effort to develop and disseminate platform technologies for engineering biology across the Labs and with interagency and private sector partners.

- More clearly define the mission, roles, and responsibilities of DOE and the Labs as a part of the national biosecurity framework, as well as provide intramural and extramural programmatic support and authorities for the DOE biosecurity mission. The Labs have unique expertise concerning biological threats that are critical for human biological research related to biosecurity.

- Launch a Biosecurity Reserve Corps to better allow nongovernmental experts to surge into cooperation with the Labs when potentially-significant biological threats emerge.

- Re-establish the Chemical and Biological Nonproliferation Program (CBNP) within the DOE. CBNP was a vital program established in 1997 that developed a wide variety of capabilities, technologies, and demonstrations to address biological and chemical threats.[7]

- Integrate the Labs better into the wider bioeconomy. This includes developing a permanent coordination framework that simplifies the interface for tapping into the resources and capabilities of the Labs, incentivizes the Labs to coordinate their activities and enhance cooperation in biotechnology, and facilitates public-private partnerships and technology transition particularly with leading private sector centers of biotechnology.

This briefer begins with a short overview of the DOE Labs, including capabilities and characteristics that enable them to prove that they are a critical element in addressing historic and ongoing biological threats. The briefer will then elaborate on the specific recommendations above, reinforced by examples as ways to

[7] United States Government, *Integrated Chemical and Biological Defense Research, Development, and Acquisition Plan: Chemical & Biological Point Detection Decontamination Information Systems* (2003). 7 - 82.

enhance and better integrate the DOE Labs in the biological threat response space. Finally, it will end with a set of critical points on implementation. With these steps, DOE can make significant progress in tapping the full potential of the Labs in effectively addressing biological threats.

CAPABILITIES OF THE NATIONAL LABS FOR ADDRESSING BIOLOGICAL THREATS

Across the 17 DOE National Laboratories, there are wide-ranging assets for contributing to national efforts to address biological threats.[8] These include world-class facilities, experts across a range of disciplines, and strong relationships with other government agencies, academia, and private companies.[9] These capacities are most visible when biological threats emerge and affect the U.S. and the world.

The United States was fortunate to have the Labs' expertise as the 2001 anthrax attacks unfolded following the September 11 terrorist strikes. Sometimes referred to as the Amerithrax incident, this event caused 22 infections, including 5 deaths, over a billion dollars spent to decontaminate attack sites, and immense psychological and political impact in the United States and abroad due to the spread of anthrax spores via letters sent through the U.S. Postal Service.[10] As Amerithrax transpired, the U.S. government put together a team of experts with diverse backgrounds in biomedicine, bioinformatics, forensics, engineering, and biodetection and analysis from Lawrence Livermore National Laboratory (LLNL) and Los Alamos National Laboratory (LANL) to set up a field-ready system of detection and analysis technologies for pathogens in the nation's capital. This resulted in the implementation of the Biological Aerosol Sentry and Information System (BASIS) - a system that reduced the time for detecting a biological agent's release from days or weeks to less than a 24-hour period.[11]

Further, facilities and capabilities such as exquisite imaging and computational biology that the Labs possess allow scientists to innovate ways of characterizing, analyzing, and monitoring biological specimens---critical steps in identifying both promising biological specimen candidates for novel applications and potential biological threats. An important element of the Amerithrax investigation was determining the age of the anthrax spores. Knowing this key piece of information would provide a rough idea of when the anthrax used in the attacks was produced. Fortunately, assets like the Center for Accelerator Mass Spectrometry at LLNL provide researchers with access to state-of-the-art instruments and analytical techniques. This Center developed critical advances in the areas of forensic science and its applications.[12] These applications, such as carbon dating methods for biological samples, were pivotal in providing preliminary data on the age of anthrax spore samples: the essential information the investigation required to generate a temporal window of when the material was produced.[13]

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[8] See further details on the 17 DOE National Labs in Appendix A

[9] Department of Energy, The State of the DOE National Laboratories (2020), 7 - 9.

[10] United States Department of Justice, *Amerithrax Investigative Summary* (2010), 1- 16.

[11] Stephen Wampler, "Lab's Work Provides BASIS for Biodetection," *Lawrence Livermore National Laboratory*, September 7, 2011.

[12] Department of Energy - Lawrence Livermore National Laboratory, "A Brief History of CAMS."

[13] For examples, see National Research Council, *Review of the Scientific Approaches Used During the FBI's Investigation of the 2001 Anthrax Letters* (2011), 73 - 75 and Appendix A.

Finally, the Labs occupy a unique space at the nexus of science mobilization and national security. This distinct vantage point allows the Labs to both lead and support in the characterization and development of technical solutions. This was particularly visible during the COVID-19 pandemic when DOE set up a virtual laboratory to mobilize it's Labs' facilities and experts at a single point of contact.[14] Funded through the CARES Act of 2019, the National Virtual Biotechnology Laboratory (NVBL) brought the best of core Lab capabilities online to function as one integrated team across the entire complex. The NVBL has provided significant benefits during COVID through 1) developing complex epidemiological modeling leveraging the world's fastest supercomputers; 2) leveraging advanced materials and additive manufacturing capabilities to help address supply chain issues for critical medical supplies, equipment, and personal protective gear; 3) assisting in molecular design through artificial intelligence, materials characterization, and nanoscience research to produce promising therapeutics for COVID; 4) gathering and using data to better understand the emergence, circulation, and resurgence of COVID and future pathogenic microbes; and 5) providing access to supercomputer-driven simulation and model capabilities to interested researchers working towards ending the COVID pandemic at the local, state, regional, and national levels.[15] While less of a concern in the COVID response, the Labs also are uniquely situated to work across the government and private sectors, with facilities, scientists and staff capable of operating in both the classified and unclassified domains.

This blend of expertise, facility capabilities, and innovation hubs has allowed the Labs to catalyze new testing capabilities, identify novel targets for medical therapeutics, generate real-time and predictive epidemiological models of COVID-19 spread, and shatter bottlenecks in the supply chain process through materials science and additive manufacturing.[16] With a few new policies and programs, the Labs can build on these contributions and maximize how their capabilities contribute to future efforts to address biological threats rapidly and effectively.

RECOMMENDATIONS

The Labs have contributed to the safety, security, and prosperity needs of the United States, its allies, and the world from past to present, and there is no need for this trend to cease. In fact, there are ways to further leverage the unique capabilities of the Labs to meet present and future challenges in the biothreat space. While fully leveraging the bio-relevant capabilities of the Labs will take time, the following ideas can be put in motion immediately.

Make DOE and the Labs Leaders in Engineering Biology for the Bioeconomy and for Biosecurity

One of the most profound developments of the 21st Century will be the evolution that is already taking place in bioeconomies around the world through the convergence of genomics, synthetic biology,

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[14] David Kramer, "DOE Launches 'Virtual' National Lab to Counter Coronavirus," Physics Today, April 28, 2020.
[15] United States Department of Energy, "NVBL Projects."
[16] Philip Rossetti, "Publicly Funded National Labs Important to U.S. Innovation," *American Action Forum*, February 14, 2018.

engineering, and computation in what is referred to as engineering biology. In the United States, companies and academics are at the forefront of driving the basic and applied research advancements that contribute to engineering biology. Though the U.S. government has begun to shift toward a more proactive position in the field, this transition remains somewhat limited to biological threat response: monitoring and defending against biological threats and responding to infectious disease threats after they emerge.

The optimal strategy for both U.S. security and economic interests is to ensure the nation remains at the cutting edge of the life sciences consistently over the coming decades, and equally across the public and private sectors. This transition is necessary to move from reactive to proactive efforts to address biological threats. Given their unique expertise, capabilities, and innovative potential, it is clear the DOE Labs should play a key role in this strategic shift by augmenting its existing capabilities to become a leader in engineering biology.

Many of the necessary ingredients for this already reside in the Labs: expertise in synthetic biology, artificial intelligence and machine learning, materials sciences, computational sciences, and the identification, detection, classification, and characterization of biological specimens. The facilities in these spaces allow experts to collaborate and do everything from field testing capabilities to conducting cutting edge basic research that opens the door for new applications in the life sciences. The Labs also serve as hubs of innovation that transfer technologies between the public and private environments - a connection that is not nearly as established in other parts of the interagency. What is missing is the identification of engineering biology as a DOE priority for the bioeconomy and biosecurity, and a focused effort to fill gaps in capabilities and to recruit world-class talent specializing in integrating the convergent fields that contribute to engineering biology.

The Labs should host world-class infrastructure for cutting-edge engineering biology, and DOE should provide the intramural and extramural programmatic support necessary for the Labs to lead and to create meaningful partnerships with academia and the private sector. Leadership in engineering biology is more critical than ever in a 21st century that is rife with security threats. As the Labs are more fully leveraged to cement U.S. primacy in the life sciences, these spaces will produce a whole host of field-ready capabilities in areas of biological detection, attribution, and the accelerated research, development, and manufacture of rapid medical countermeasures. As these capabilities are brought online in the coming years, enhanced proficiencies in these critical areas can have great benefits towards deterring and dissuading adversaries from cultivating biological weapons programs.

Clarify Authorities and Interagency Dependencies for the DOE Biosecurity Mission

DOE has not always had a recognized seat at the table in the biosecurity mission space. Fuller and clearer authorities would better empower DOE to operate in the biological space and to dedicate appropriate resources to this mission. As one example of the lack of clarity, DOE was not originally listed as a primary member of the cabinet-level Biodefense Steering Committee (BSC) established in 2018 National Security Presidential Memorandum (NSPM) 14 for "monitoring and coordinating the implementation of the [National Biodefense] Strategy."[17] The Labs have clear utility in addressing all five goals in the National Biodefense Strategy, and the DOE participated in the drafting of both the Strategy and the Implementation Plan.[18] Recognizing the important role of DOE and the Labs in biosecurity, the Secretary of Health and Human Services (HHS) subsequently invited the Secretary of Energy to join the BSC as a permanent primary member, and this was finalized in a revision to the charter in September 2020 during the COVID crisis. While operational agencies such as DOE and HHS work well together and understand their respective capabilities and roles, there remains confusion in Congress, in the Office of Management and Budget, and in policy organizations such as OSTP and the National Security Council regarding the appropriateness of full DOE participation in biosecurity matters.

A second concern is a lack of clarity and consistency in terms of programmatic support for the Labs from other biosecurity mission agencies. For example, following the establishment of the Department of Homeland Security Science and Technology Directorate (DHS S&T) in 2003, the Labs were sponsored to serve at DHS S&T to help develop and manage research and development for the directorate. These efforts included highly salient areas in addressing biological threats like the research and development of assays, detection systems, bioinformatics systems, and operational support. One of the most visible, and most-discussed, technologies associated with this merger was the BioWatch system---an early-warning detection system for certain pathogens that may have been released in the environment for deliberate, offensive purposes.[19] However, the expertise housed within the Labs was sidelined as DHS stood up its own initiatives and operations. Experts from the Labs were phased out in key ways, including denial of access to S&T planning meetings on projects that Labs had helped set up.[20] It is impossible for the Labs to plan for necessary facilities, resources, and personnel that other agencies might need to leverage for biosecurity without predictable, long-term support and relationships.

Clearly defined authorities would help ensure that the unique expertise and capabilities of the Labs are effectively put to work in biosecurity matters across the interagency. A consistent understanding of responsibilities within the interagency biosecurity space is necessary to better leverage the Labs for biosecurity work and also to facilitate enduring partnerships with academia and the private sector.

Create a Biosecurity Reserve Corps

The Executive Branch and Congress should create a system to strengthen the nation's ability to leverage top talent across public and private sectors. One such system could be a Biosecurity Reserve Corps. Somewhat akin to the National Guard, nongovernmental experts could sign on for a period of service via the National Labs. This could entail a minimal annual time commitment (for example, 5 days per year) spent networking with Lab counterparts and collaborating with them, and allow Corps members to be pre-credentialed and cleared in order to surge into national service if their help is required to urgently address an emerging biological threat.

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[17] The White House, "Presidential Memorandum on the Support for National Biodefense," September 18, 2018.
[18] The White House, *National Biodefense Strategy 2018, 6 - 7.*
[19] A.M. Waters, *LLNL and DHS Science and Technology Directorate - Historical Relationship* (2018), 4 - 7.
[20] Ibid.

This system would be advantageous in three ways compared to the status quo. First, lowering the barriers for DOE experts to build and maintain formal relationships with private industry and academics is necessary to keep the United States on the cutting edge of the life sciences and the disciplines it affects. Disciplines like synthetic biology show that the life sciences have become de-siloed - as subject areas like engineering, computer science, and data informatics continue to gain greater relevance in the life sciences, it is extremely unlikely that all relevant expertise will be found in one location. Therefore, building the networks now is of vital importance to the United States' global position in science and technology research and development, as well as providing a regular mechanism for experts across the public and private sectors to trade ideas and to build interpersonal relationships ahead of a crisis.

Second, when biological threats emerge, the nation could build on this Biosecurity Reserve Corps concept and the network it promotes to enable swift action with minimal operational and bureaucratic barriers. During such events, Corps members would already be pre-credentialed to facilitate onsite access to Labs. All necessary paperwork and agreements would be completed before a crisis strikes. Eliminating delay through pre-credentialing Biosecurity Reserve Corps members enables a faster response time to more immediately address a biological threat while minimizing the operational burden in a swiftly-evolving emergency environment.

Finally, the Biosecurity Reserve Corps could allow the Labs to better compete in attracting and retaining the best and the brightest scientific and engineering minds. Some recruitment and retention issues at the Labs derive from common competition with companies that offer high salaries and other perks. Such problems also stem from cultural changes: historically, career models for laboratory staff were usually based on long-term and stable work experiences - it was not uncommon for individuals to have one or two positions for significant stretches of time until retirement. In contrast, current trends indicate that people are comfortable changing job positions more frequently in order to have a wider variety of experiences.[21]

The Biosecurity Reserve Corps can help overcome these challenges, as talented people will not have to choose this lifestyle over public service---and it will help the U.S. government tap into the many benefits that can come from experts taking on diverse experiences. To facilitate a strong start to the Corps, more analysis should be done on the incentives and disincentives that influence younger generations as they consider working in government versus other sectors. In addition, this should include an analysis of the rate and implications of retirement in particular areas of the national security enterprise.

Re-establish the Chemical and Biological Nonproliferation Program

CBNP was established in 1997 in response to growing concerns of chemical and biological weapon capabilities and their potential use by adversary state and non-state actors. This program was housed in the DOE with a crucial national security mission: to develop, demonstrate, and deliver technologies that

[21] Trent Northen, Nancy Hagel, Daniel Sinars, Johnny Green, Dawn Wellman, and Daniel T. Schwartz, *Attracting and Retaining Top Scientists and Engineers at U.S. National Laboratories and Universities: Listening to the Next Generation* (2018), 1 - 6.

improve domestic defense capabilities and save lives due to chemical and biological attacks.[22] The program resulted in a number of innovative solutions to achieve that mission, including detectors and diagnostics for chemical and biological threats.

Eventually, as with many Lab projects with biosecurity implications, CBNP was moved to the newly-established DHS in 2003.[23] Again, the transfer of a biosecurity program from the Labs to DHS contributed to the loss of DOE input in significant areas related to addressing biological threats. An analogous program should be reestablished in DOE, especially given the above-noted advantages in applying technological changes to this mission---infrastructure that DHS simply does not have. This work should still be tightly coordinated with interagency counterparts to avoid replication and best leverage all federal assets, but the Labs need an independent program to ensure their input and projects are not lost in pursuit of countering biological and chemical threats..

Integrate the Labs into the Wider Bioeconomy Ecosystem

Historically, the Labs have been underleveraged when it came to public-private partnerships. A contributing factor to this issue is how geographically distant many of the Labs are from metropolitan regions - and, in particular, metropolitan regions hosting significant concentrations of private companies and academic institutions researching and innovating in the life sciences.[24] While this geographic chasm was generated deliberately due to the security-focused and sensitive nature of the Labs' early missions, this severely limits the Labs in building the necessary public-private partnerships to help fulfill some of their vital missions in areas like technology transfer for commercialization.[25]

Therefore, it is essential to develop a permanent coordination framework that facilitates public-private interactions, simplifies the interface for tapping into their resources and capabilities, and incentivizes the Labs to collaborate and build bridges with the private sector. The Labs can take lessons learned from successes such as the NVBL to explore future platforms that are oriented more towards developing and accelerating the bioeconomy and to further engage with geographically-distant private entities, interagency partners, and other stakeholders who also can contribute to the biosecurity mission as needed.

IMPLEMENTATION

Implementing these recommendations will require action in several cross-cutting areas of activity. Steps to facilitate progress include the following.

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[22] U.S. Department of Energy's Defense Nuclear Nonproliferation Office, *Chemical and Biological Nonproliferation Program: FY99 Annual Report*, 5 - 9.

[23] Counterproliferation Program Review Committee, *Report on Activities and Programs for Countering Proliferation and NBC Terrorism* (2003), 11 - 12.

[24] CBRE, "U.S. Life Sciences Report 2020."

[25] Scott Andes, Mark Muro, and Matthew Stepp, *Going Local: Connecting the National Labs to their Regions to Maximize Innovation and Growth* (2014), 5 - 9.

Enable Full DOE Representation on Bio-Related Matters. Despite their utility in biological research, development, and application across a wide range of sectors, DOE has too often been left out of committees or councils that deal with bio-related matters. The roles of DOE leadership and the Labs in vital biosecurity coordination efforts like the Biodefense Steering Committee created through NSPM-14 and associated working groups need to be clarified, and they should participate in future biosecurity strategy documents and convening bodies. DOE personnel should also be present for key interagency decisions and deliberations - for example with bio-related discussions convened by the National Security Council (NSC) and Office of Science and Technology Policy (OSTP).

Implement Biothreat-related Projects that Fully Utilize DOE Labs and their Expertise. Improving on the success of platforms like the NVBL as well as research, development, and deployment of detection technologies are key to addressing the next pandemic. Now is the time to build on past programs like CBNP and generate new initiatives that both enhance our efficiency at detecting and forecasting pathogens of concern. This is vital to the nation's and the global community's continued health and security. A good example of progress on this issue is the $30 million being requested for DOE to prepare Americans for future pandemics in FY22 as part of the American Jobs Act, and the $22 million request in the FY22 budget for the Biopreparedness Research Virtual Environment (BRaVE) proposal to build on the success of the NVBL.[26]

Improve Communications. For many policymakers and influencers, the public, and even personnel across U.S. government agencies, there is a lack of full appreciation for how deep DOE's capabilities are in terms of reducing biological risks. DOE officials and other stakeholders should develop stronger messaging and outreach strategies as a foundation for improving policies and practices surrounding the Labs.

Rededicate the National Nuclear Security Administration (NNSA) to the biosecurity mission. Though its focus is on nuclear matters, in particular the U.S. nuclear weapons stockpile, those leading the NNSA are key decisionmakers and advisors to the Secretary of Energy (and White House leadership) broadly in matters of national security. Undertaking the strategic shift toward the Labs leading in engineering biology, and other recommendations outlined above, would benefit from the advice and ideas of NNSA leaders---in addition to making sure meeting the full biosecurity potential of the Labs is harmonized with other DOE missions. The CBNP has a natural home within the NNSA and its laboratories.

Leverage the Labs' Systems Thinking. Improving national security requires systems-level thinking and problem-solving for which the Labs are uniquely suited. As the threat space continues to evolve (and defy the boundaries of government programs that too-often compartmentalize solutions), diverse input and expertise are necessary to address a national security space that is becoming increasingly de-siloed and complex. The Labs are historically unique in being managed in ways that encourage the multidisciplinary approaches necessary to countering modern threats.

[26] White House, *Budget of the U.S. Government: FY2022*, 46.

CONCLUSION

The DOE Labs are often described as the "crown jewels of the nation's research and innovation ecosystem."[27] Their past and current performance in the area of biological threats makes it clear that this phrase is a perfect description for the Labs: spaces where some of the brightest minds in the United States gather and use cutting-edge equipment and facilities to help drive the efforts necessary for the nation's health, security, and prosperity. By further leveraging and empowering the National Labs, the United States can continue to reap the benefits of these critical assets, and be better prepared for the complex risks of the 21st century.

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ACKNOWLEDGEMENTS

The authors and the Council on Strategic Risks would like to thank the team of government, academic, and private sector experts who convened (virtually) to help us define and explore these recommendations on a non-attribution basis.

[27] Department of Energy, "Impact of DOE's National Labs Felt Both Locally and Internationally," December 22, 2016.

APPENDIX A: ABOUT THE DOE LABS

The DOE Labs have a rich history that has led to them taking a more prominent role in addressing biological threats. This appendix provides a small bit of additional detail on their structure and roles as background to the changes recommended above.

Cutting-edge work at the nexus of science and national security is conducted across the agency's network of 17 Labs across the United States. Their work includes energy innovation, science discovery, nuclear security and weapons activities, and environmental cleanup. They also contribute significantly to research and development in the basic and applied life sciences through initiatives such as the Human Genome Project in the 1990s, the Biological Aerosol Sentry and Information System (BASIS) in the 2000s, and biological detection platforms like the Lawrence Livermore Microbial Detection Array in the 2010s.[28]

The Labs vary in capabilities, structure, and aims, as well as in how they support technical efforts across the interagency and in public-private partnerships. Some Labs are considered energy technology laboratories. Others are considered multipurpose science laboratories, with unique research programs, core capabilities, and facilities that enable cutting-edge scientific research and outcomes. Yet others are considered single-program science laboratories, which focus exclusively on basic science. Finally, multipurpose security laboratories are fundamental to the security mission related to nuclear, chemical, biological, and radiological threats and support efforts to address such threats through cutting-edge science and engineering in both the open and classified domains. Figure 1 shows how the Labs are distributed across these categories.[29]

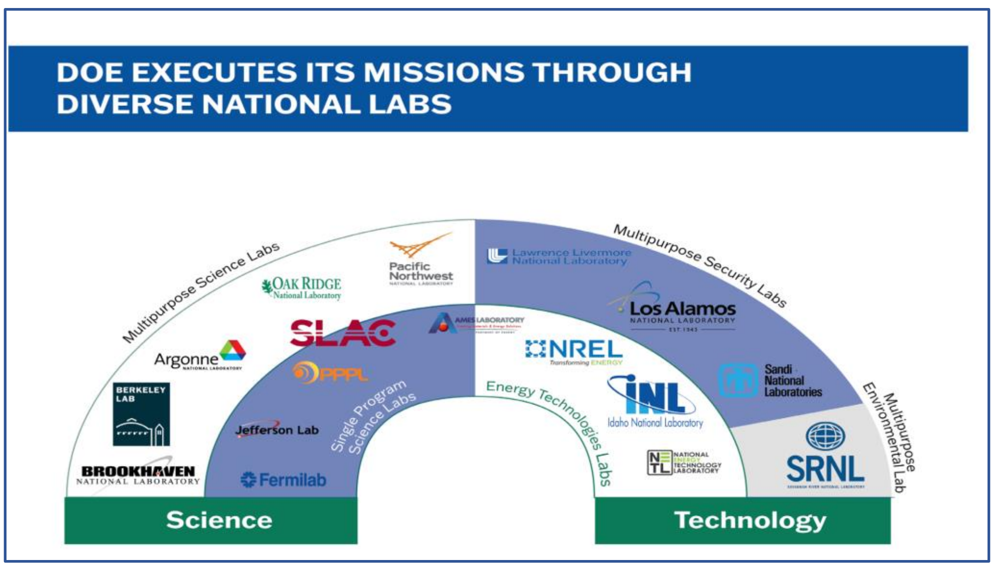

Figure 1: Distribution and Typology of National Labs (Credit: Department of Energy)

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[28] For examples, see "What is the Human Genome Project," *National Human Genome Research Institute*, October 28, 2018; Stephen Wampler, "Lab's Work Provides BASIS for Biodetection," *Lawrence Livermore National Laboratory*, September 7, 2011; and "Microbial Detection Array," *Lawrence Livermore National Laboratory*.
[29] *The State of the DOE National Laboratories* (2020), 14 - 15.

The Labs have expanded significantly in number, missions, and scope since their emergence in World War II. Compared to the goal of designing and producing the world's first nuclear weapons in the 1930s and 1940s, the Labs now face myriad challenges ranging from the need for innovation in energy and materials to the detection and attribution of chemical, biological, radiological, and nuclear threats, including biological threats from natural, accidental, and intentional sources.[30]

The Labs house exceptional multidisciplinary expertise. In basic science research alone, experts from the Labs have discovered 22 of the 118 elements on the periodic table and received 118 Nobel Prizes.[31] This in-house expertise has enabled innovation across the spectrum of science, technology, engineering, and mathematics disciplines, including those listed in Figure 2.[32]

National Laboratory Core Capability Categories:

- Accelerator S&T
- Advanced Computer Science, Visualization, and Data
- Applied Materials Science and Engineering
- Applied Mathematics
- Biological and Bioprocess Engineering
- Biological Systems Science
- Chemical and Molecular Science
- Chemical Engineering
- Climate Change Science and Atmospheric Science
- Computational Science
- Condensed Matter Physics and Materials Science
- Cyber and Information Sciences
- Decision Science and Analysis
- Earth Systems Science and Engineering
- Electrical & Mechanical Design & Engineering
- Environmental Subsurface Science
- Large-Scale User Facilities/Advanced Instrumentation
- Materials Science, Engineering & Advanced Manufacturing
- Materials & Component Prototyping, Manufacturing, Production & Integration
- Mechanical Design and Engineering
- Nuclear and Radiochemistry
- Nuclear Physics, Nuclear Chemistry & Nuclear Engineering
- Particle Physics
- Plasma and Fusion Energy Science
- Power Systems and Electrical Engineering
- Systems Engineering and Integration
- Weapons Systems Design, Engineering, Integration & Testing

Figure 2: National Laboratory Core Capability Categories (Credit: Department of Energy)

[30] The Commission to Review the Effectiveness of the National Energy Laboratories, *Securing America's Future: Realizing the Potential of the Department of Energy's National Laboratories, Volume 1: Executive Report* (2015), 5 - 15.

[31] First, national laboratories are responsible for discovering nearly 20% of all the elements on the periodic table. Second, the exceptional number of Nobel Prize winnings is not just a historical footnote - for example, from 2015 - 2020, national laboratory experts were the recipients of 38 Nobel Prizes. See U.S. Department of Energy, *America's National Laboratory System: A Powerhouse of Science, Engineering, and Technology* (2017), 1 - 36; *The State of the DOE National Laboratories* (2020), 16; and Department of Homeland Security - Science and Technology Division, *DHS and DOE National Laboratories: An Enduring Partnership* (2021), 1 - 2.

[32] *The State of the DOE National Laboratories* (2020), 17.

The Labs are also known for their cutting-edge facilities that house some of the world's most unique and advanced scientific instruments and tools. A well-known asset housed in Labs lies in their hosting some of the world's fastest supercomputers---extremely powerful computers whose speed and capacity enable researchers to model and analyze complex biological, chemical, nuclear, novel materials, climate change, and energy-related systems.[33] These supercomputers are also integral to ensuring the safety, security, and effectiveness of the U.S. nuclear stockpile and contribute to U.S. support of the Nuclear Test Ban Treaty. This, alongside other technologies and resources like large-scale particle accelerators, lasers, nanoscience and genomic centers, x-ray light sources, and neutron sources play a significant role in Labs and their unique abilities.[34]

These capabilities are all necessary components of a robust system required to detect, understand, and address biological threats. It is imperative that these assets be expanded upon as described in this briefer in order for the United States to maintain a leading bioeconomy, prevent future pandemics, and halt and deter deliberate biological threats.

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[33] National Nuclear Security Administration, *NNSA Supercomputers Recognized Worldwide for Speed and Performance* (2020).

[34] For examples, see *The State of the DOE National Laboratories* (2020), 10; and Department of Energy, "NVBL Projects," *Department of Energy's Office of Science*.