# OPPENHEIMER SCIENCE AND ENERGY LEADERSHIP PROGRAM

## LEADERSHIP, INNOVATION, EXCELLENCE

## OSELP Cohort 6 Think-Piece Report December 2023

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Cover image: Cohort 6 at the December 13, 2023 Capstone event in Forrestal.

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# Reimagining the Implementation of the FFRDC Model

Christian Petrie (ORNL), Emily Smith (AMES), Matt Toups (FNAL), Jimmy Fung (LANL), Mark Kemp (SLAC), Lance Kim (LLNL)

- *What: Delivering on today's unprecedented DOE and NNSA missions will require changes to the implementation of the FFRDC model to improve laboratory inefficiencies in an era of heightened oversight.*
- *Why: DOE missions are more urgent and diverse than ever before, there is actionable momentum from recent DOE-led reform efforts, and the LOB is invested in this cause as evidenced by their related initiative to reimagine the FFRDC model.*
- *How: We propose cataloguing recent successful (and unsuccessful) reform efforts within the national lab system, extracting common themes, and organizing a workshop to disseminate these findings, share best practices, and encourage broader adoption of successful reform mechanisms.*

## Overview

The Federally Funded Research and Development Center (FFRDC) model for the management and operation (M&O) of the US Department of Energy's (DOE's) national laboratories has historically ranged from a "hands off" approach with little direct oversight during the Manhattan Project and the decades that followed to a "hands on" approach with elements of micromanagement in the 1980s to early 2000s. Today the missions of the national laboratories are just as critical and significantly more diverse since their inception, and the DOE seeks to achieve its mission through a FFRDC model that balances operational freedom with measured oversight. Numerous reports over the past few decades recommended how to improve efficiency and oversight models to enhance mission delivery. At the same time, a large portion of the federal and contractor workforce has spent fewer than five years within the laboratories and/or DOE, resulting in a general lack of familiarity with the special relationship that is intended between the laboratories and the federal government.

This think-piece reviews recent actions that have been taken to address inefficiencies stemming from an imbalance of compliance versus mission focus, including common themes and mechanisms for affecting change. We recommend expanding our initial observations to develop a more comprehensive summary of successful reform efforts as well as obstacles that have prevented certain efforts from being successful. Finally, we propose working with the Laboratory Operations Board (LOB) to organize a workshop to share lessons learned and best practices, and foster conversations on how to achieve an optimal balance of operational freedom and oversight of the DOE's FFRDCs.

## Process

We reviewed many documents focused on laboratory performance and mission execution and the recommendations that have been made to improve operational efficiencies. These included the 2003 Blue Ribbon Commission report [1], the 2015 CRENEL report [2], a recent summary of concerns with FFRDCs prepared for Congress [3], multiple Government Accountability Office reports [4, 5], Office of Inspector General (OIG) audit reports [6], the Enhanced Mission Delivery Initiative (EMDI) [7], the Revolutionary Working Group (RWG) [8], and other summaries of the FFRDC model [9].

We spoke with:

- Lynn Orr, former DOE Under Secretary for Science and Energy

- Mike Knotek, former DOE Under Secretary for Science and Energy
- Juston Fontaine, DOE Office of Science, Deputy Director for Field Operations
- Ingrid Kolb, DOE Office of Management, Director
- Johnny Moore, DOE, Oak Ridge Site Office Manager
- Mark Peters, Battelle Memorial Institute, Executive Vice-President for Laboratory Operations
- John Sarrao, SLAC National Accelerator Laboratory, Director
- Carolyn Zerkle, Lawrence Livermore National Laboratory (LLNL), Deputy Director
- Mike Schlender, Pacific Northwest National Laboratory (PNNL), Chief Operating Officer
- Juan Alvarez, Idaho National Laboratory (INL), Chief Operating Officer
- Tim Meyer, Princeton Plasma Physics Laboratory (PPPL), Chief Operating Officer
- Devon Streit, PNNL, Director of Institutional Planning
- Saurabh Anand, SLAC National Accelerator Laboratory, Chief Laboratory Counsel
- Peter Raboin, LLNL, Associate Program Director for the Nuclear Weapon Engineering Program
- Chelsey Aisenbrey, Ames Laboratory, Director of Laboratory Planning and Performance

## Challenge

Many of the DOE national laboratories were born out of the Manhattan Project to urgently "mobilize the country's scientific and engineering talent and apply it to the development of technologies that would aid U.S. war efforts" [3]. This led to the development of FFRDCs (initially called Federal Contract Research Centers), which were not subject to many of the restrictions of the federal government. For example, under the government-owned, contractor-operated (GOCO) model, FFRDCs had fewer restrictions on hiring and pay rates, which led to the development of the scientific and technical talent necessary for the massive undertaking for the war effort. The GOCO model provided the management and operational freedom needed to solve an urgent national need. However, the "hands off" oversight approach used in the 1940s through 1980s was not without consequences as it, for example, helped contribute to significant environmental and worker safety issues, primarily from byproducts of nuclear weapons production.

Today, 16 of the 17 DOE national laboratories still operate under the GOCO model, but with a significantly different oversight approach, at least since the early 1980s. The late 1980s through early 2000s saw periods of increasing complexity in the regulation ("micromanagement") and oversight ("transactional") of FFRDCs. Reports have claimed that this lack of trust and accountability affected mission execution, degraded operational efficiencies, and limited operational freedom—originally envisioned to be necessary to solve urgent National needs and drive innovation [2]. DOE now seeks to balance continued congressional and OIG concerns regarding a lack of oversight of FFRDCs [3, 5] with allowing the labs sufficient operational freedom. This is challenging! Laboratory and DOE employees hired within the past five years may not appreciate their intended strategic relationship that, per Federal Acquisitions Regulation 35.017, is expected to be "long term" and provide the continuity that will attract high quality personnel.

The fundamental challenge of balancing compliance versus mission delivery is particularly acute today given the unprecedented pressure on DOE to deliver on some of its most critical missions. Escalating geopolitical tensions have prompted massive programs to modernize our nuclear weapons systems and more broadly enhance our nation's strategic nuclear deterrence mission. Much of the DOE and lab workforce — many of whom were born in an era where American society was reaping the benefits of the post-Cold War peace dividend — does not fully comprehend the urgency of the National Nuclear Security Administration's (NNSA's) mission with the renewed strategic conflict between great powers and near-peer rivals. At the same time, funding levels for the development and deployment of clean energy technologies have never been higher and it is a challenge for DOE to even distribute the funding, let alone execute the work. It is clear that we need to make changes in the way that we implement the FFRDC model to deliver on DOE's urgent and ambitious missions.

### Recommendations

This think piece does not add to the long list of reports that provide recommendations for how to improve DOE oversight models or laboratory relationships. Alternatively, we suggest learning from recent successful (and unsuccessful) reform efforts within the national lab system, extracting common themes, and disseminating these findings to a broader audience to share best practices. Through this, we aim to stimulate revitalizing the DOE FFRDC model to return closer to its roots, which held great promise for effective mission delivery.

We aren't alone. Jill Hruby championed the Enhanced Mission Delivery Initiative (EMDI) to improve efficiencies within the National Nuclear Security Administration (NNSA) labs [7]. Since it was issued, there has been measurable progress in implementing the EMDI recommendations. The Office of Science has had similar success in developing the HR Benefits Toolkit and reinvigorating the FFRDC model through efforts such as the Revolutionary Working Group (RWG) led out of SLAC National Accelerator Laboratory [8]. Finally, this think piece hopes to leverage parallel activities that are being considered by the LOB. The LOB's initiative is considering how to reimagine the FFRDC model to maintain the originally intended "special" relationship between the government and the laboratories, including identifying any applicable federal policies and regulations that may need to be revised. This think piece complements the LOB's efforts in that it takes a more pragmatic approach to addressing inefficiencies within the current FFRDC model, rather than reimagining the FFRDC model itself. It is easy to point to some of these more visible successes, but there have also been instances where reform efforts have been unsuccessful. We hope to capture both the successes and failures to inform future reform efforts.

Thought leaders throughout the complex were overwhelmingly supportive of the idea of focusing on mission rather than compliance. All recognized that there are instances of processes that have evolved to run contrary to this philosophy. Of course, the focus on mission shouldn't be conflated with "mission delivery at all costs." Safe, secure, and responsible execution is necessary for mission delivery to be effective. However, at least three factors push us away from this ideal.

1) Poor understanding of risk acceptance. There is not a shared understanding of who is responsible for accepting and managing risk (lab management, contractor, site office, etc.). Ultimately, decisions must be made on how much risk is acceptable for achieving mission results. Typically, poor performing institutions have shorter leashes as they demonstrate the ability to execute mission effectively. However, feedback was received that regardless of performance, it is very common as directives flow down through organizations, instead even more constraints are added. Labs frequently are their own worst enemies.

2) Directives originating from outside entities. Federal directives can be powerful tools to broadly implement needed changes. Like many things, good intentions can later be found to have substantial flaws or better alternatives can be subsequently discovered. When a directive originates from outside of DOE, for example, it can be incredibly difficult to change or reverse.

3) Siloed organizations optimizing local problems. Frequently, we heard about groups that may have good intentions trying to achieve a reasonable objective while inadvertently grinding mission achievement to a halt.

**Recommendation 1:** Compile recent successes, mechanisms for affecting change, continued pain points, and reasons why certain ideas were not successful to inform future reform efforts.

The time and effort required to fully catalogue and assess all recent reform efforts would stretch beyond the duration of the Oppenheimer Science and Energy Leadership Program Cohort 6. Nevertheless, we have some initial observations based on the many conversations we had with current and former leaders at DOE and its national laboratories. These observations are summarized in Table 1 and will provide momentum for any future compilations that may continue if this think piece is supported by the National Laboratory Directors Council (NLDC). Future compilations would be performed by this think piece team and reviewed and approved by the NLDC and/or the LOB in support of their fiscal year 2024 initiative. With support from the NLDC/LOB, we propose communicating the findings to a broader audience via the workshop described later in recommendation 2.

**Table 1.** Initial summary of some recent successful reform efforts across the DOE national lab system.

| Approach | Successes | Limitations |
|---|---|---|
| ***Create, change, or remove directives*** | • DOE Order 413.3B (acquisition of capital assets) was changed to increase the threshold for capital assets from >$20M to >$50M. | • Original request was a limit of $750M, whereas a more modest request of $100M might have been granted.<br>• Change took 2.5 years. |
| | • NNSA issued a supplemental directive that allowed for waiving of DOE Order 413.3B requirements for low-risk commercial like construction and adopt OSHA+ standards. | • Required years of successful pilot projects[1].<br>• Limited to non-complex, non-nuclear construction under $100M. |
| | • DOE Order 5801.1A removed requirements related to personal property management was based on feedback from lab and DOE staff. | • None. |
| ***Piloting relaxed requirements or reduced reporting frequencies*** | • NNSA pilot program increased procurement consent approval authority from $20M to $50M. | • Not applicable to construction or nuclear facilities.<br>• Took 6 months to implement.<br>• At LLNL, only impacted 4 contracts; a $100M consent approval authority is estimated to impact dozens of contracts per year. |
| | • LLNL initiated risk-based pilots to reduce the number of annual deliverables related to cyber security (from ~200 to ~40) and emergency management (from ~60 to ~12). | • Uncertain whether requirements will change after pilots end. |
| | • LLNL submitted a variance to 10 CFR 851, Worker Safety and Health Program, to instead follow more standard Cal/OSHA construction regulations. | • Currently under DOE review. |
| | • NNSA labs piloted normalized hazard pay rates for staff employed by different labs working at the same site to improve employee relationships. | • None. |
| | • LANL worked with NNSA to pilot a Craft Incentive Program, leading to 20% increases in craft workforce. | • None. |
| ***Piloting contract reform*** | • SLAC eliminated H-clause contract requirements regarding procurement: sole source justification is no longer required for awards <$250k and site office reviews are not required for subcontracts between $5M and $25M[8]. | • None. |
| ***Change in contract management*** | • NNSA changed their M&O contract model from 5 years + 1-year extensions to 5 years + 5-year extensions. | • Currently limited to NNSA labs; not being considered by DOE Office of Science. |

[1] Example pilot projects include the LLNL Digital Infrastructure Capability Expansion, Y-12 Special Materials Facility, Y-12 Fire Station, LANL Pajarito Corridor Office Complex Building 1, and SNL Emergency Operations Center.

| Approach | Successes | Limitations |
|---|---|---|
| ***Streamlining controls on compensation and benefits*** | • The LOB championed the HR Benefits Toolkit to address recruitment/retention challenges including childcare, compensation, and benefits.<br>▪ Contributed to the revision of DOE Order 350.1 and the removal of a clause that deemed workplace dependent care facilities unallowable.<br>▪ Targeting removal of H-clause requirements for DOE to approve pre-implementation changes to compensation plans.<br>• NNSA labs worked with DOE to conduct a Geographic Differential Study to account for high cost of living areas and inform Compensation Increase Plans (CIPs).<br>• SNL worked with DOE/NNSA to modify their pension plan to allow for retirees to work more hours without an impact to their pension or other post-retirement benefits. | • Many of these initiatives are still under development. |
| ***Internal streamlining*** | • LANL increased procurement thresholds from \$250k to \$20M and removed FAR-based procurement requirements that previously required ~3 days to approve purchases >\$250k.<br>• LLNL bereavement policy was updated to remove unnecessary approvals and increase flexibility.<br>• PNNL was able to eliminate an annual strategy document that was being generated unnecessarily in place of a simple scope of work to satisfy contractor assurance requirements. | • None. |

**Recommendation 2:** We propose working with the LOB to organize a workshop to foster conversations surrounding the special nature of the FFRDC model and highlight pathways by which contractors and federal employees can work together to achieve an optimal balance of operational freedom and oversight of the DOE's FFRDCs.

Discussions focused on oversight reform and implementation of the FFRDC model are not widespread across the laboratory complex; in many cases the discussion of individual efforts may remain at their originating laboratories or within a small group of individuals in similar positions across the laboratory complex. Participants in the OSELP program have the unique opportunity to learn about many of these efforts during their fellowship year (e.g., see Table 1). Our first recommendation seeks to build upon our initial observations to provide a more comprehensive summary of recent reform efforts. Recommendation 2 focuses on disseminating this information to a wider audience across the DOE and laboratory complex, which could encourage more creative thinking and reduce impediments to broader adoption of reform mechanisms that have been successful in smaller settings. Communicating these ideas is particularly important given the large percentage of DOE and laboratory staff that are new to the complex and may not understand the intended nature of the FFRDC model.

The laboratory ecosystem is diverse with respect to size, mission, operational challenges, complexity, and relationships; reform approaches must be tailored to each laboratory. Another barrier to reform is the nature of relationships within the DOE enterprise; reform depends on action from all parties involved in

FFRDC relationships and reform efforts undertaken by a single party are often limited in their effectiveness. It is crucial that both contractors and federal employees participate in reform strategies. Programs such as Building Executive Leaders for Tomorrow (BELT) have been established to strengthen relationships between emerging federal and laboratory leaders. These programs could play a role in building the long-term trust that is needed between DOE and the labs, but we believe that a more timely solution is needed to address inefficiencies that could threaten more urgent mission needs.

To affect reform for all parties in the FFRDC relationships, the target audience for our proposed workshop includes: laboratory staff who work with the DOE site/field offices and headquarters staff, DOE site/field office and headquarters employees charged with lab oversight, sponsoring DOE program offices, and selected FFRDC staff from other federal agencies funding STEM or security research (e.g., NSF, DOD, NASA). The workshop could include a history of FFRDCs and M&O contracts; a summary of common misconceptions and challenges related to oversight; an analysis of the impact of FFRDCs on technology innovation, national security, and DOE's mission; facilitated conversations between federal employees and FFRDC representatives; and a forum to discuss emerging opportunities for improvements in mission execution (i.e., the focus of recommendation 1).

As part of this recommendation, we propose that the Oppenheimer Leadership Network, and members of this think piece team, work with the NLDC and LOB to develop the attendee list, agenda, and execute this workshop.

### Concluding Remarks

Delivering on the urgent DOE missions facing the nation requires bold and creative recipes to increase operational efficiency in an era of heightened oversight. By cataloging and sharing these solutions across the DOE lab complex, our aim is to unleash the latent productivity of the DOE's FFRDCs by bolstering federal and laboratory champions for operational efficiency and providing them with an enduring and dynamic resource to aid them in overcoming the everyday challenges they face in increasing operational efficiency at their labs. Figure 1 summarizes the activities that have been performed under this think piece, how they relate to our proposed future activities, and which activities will need to be owned by laboratory champions (NLDC, LOB, etc.).

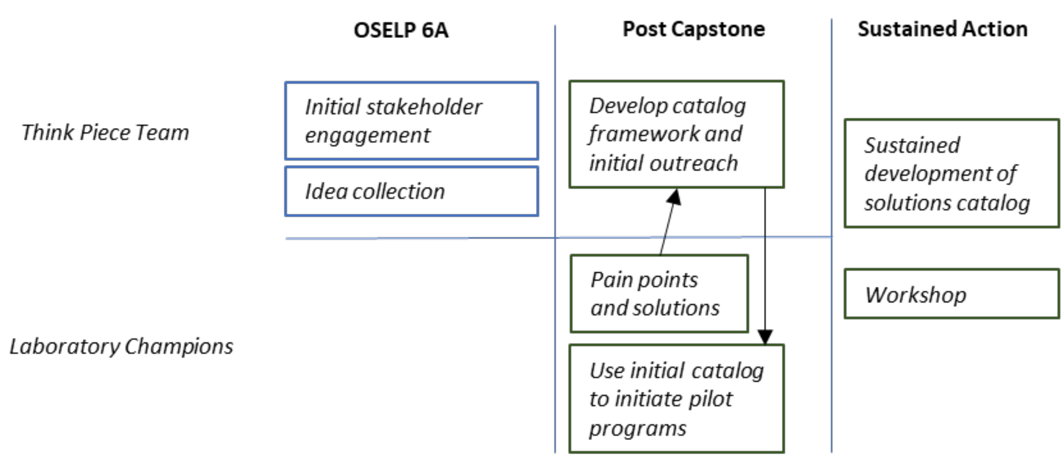


**Figure 1.** Diagram showing the evolution of the catalog described in the recommendations and the ongoing interaction with laboratory champions for operational efficiency.

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# GenAI Driven Operational Excellence Across the National Lab Complex

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## Overview

Generative AI (GenAI) has the potential to revolutionize how the DOE National Labs achieve their missions. Recent advances in these capabilities have been a catalyst for increased excitement and investment in GenAI. While these capabilities unlock opportunities, they also pose considerable challenges. The Department of Energy (DOE) and National Labs are engaged in multiple endeavors to conceptualize use cases and comprehend both the potential risks and benefits associated with integrating GenAI within the operational aspects of the DOE ecosystem. Without careful coordination, there is a possibility that labs will invest in efforts without addressing significant barriers to success upfront or develop applications for which the risks and unintended consequences are poorly understood.

In this think piece, we recommend the formation of a cross-laboratory, multidisciplinary community of practice (CoP) to facilitate the use of GenAI applications within National Labs operations. This group should consist of experts spanning various domains, including operations, computer science and information management, security, policy, and ethics. The community of practice will establish a framework for evaluating the benefits, risks, and impacts of applying GenAI to operations and will develop a process to implement and steward GenAI applications for operations at National Labs. The community of practice will champion high impact cross-lab use cases, share lessons learned and best practices, and inform DOE guidance and policy.

Additionally, the supplementary material of this think piece contains a snapshot of information on the existing initiatives and policies at each National Lab, current operational use cases under development at individual labs, and three example high-impact cross-lab use cases. This information can serve as a foundational reference for the community of practice group as they work to establish a comprehensive framework that spans all the DOE National Labs.

## Definitions

Artificial Intelligence (AI): A field of computer science that focuses on creating intelligent machines capable of tasks normally requiring human intelligence.

Machine Learning (ML): An application of AI that enables systems to learn and improve from analysis of and inference from patterns in data without being explicitly programmed.

Deep Learning (DL): A subset of machine learning, which is essentially a neural network with three or more layers.

Generative AI (GenAI): A type of AI that can create content such as images, text, audio, or video based on the data on which it has been trained, using techniques like large language models, transformer neural networks, and generative adversarial networks.

### Process

This think piece concept began when GenAI made headlines in November, 2022. The suggestions and concepts have evolved to stay in sync with the industry. We've had the privilege of gaining insights from numerous individuals across all national labs and the DOE, learning about the challenges and opportunities that GenAI introduces. While our thoughts continue to develop, our gratitude towards the individuals who will determine GenAI's role in our future remains constant. These are the individuals we've engaged with and learned from. We value their support, guidance, and constructive criticism. Appendix D includes a list of these individuals who have contributed to the formation of this think piece - we are grateful to each one of them.

### Recommendation

Develop a cross-laboratory, multidisciplinary community of practice to steward the implementation of GenAI applications for operations at the National Labs.

### Challenge

There are currently individual efforts going on at National Laboratories to incorporate GenAI applications into business operations. These GenAI applications have the potential to increase the efficiency and effectiveness of Laboratory operations, reducing costs to the taxpayer, increasing repeatability, and enabling researchers to spend more time focused on solving scientific challenges. Coordination across the labs on these efforts could support effective information sharing, increasing the impact of these individual efforts. For example, at PNNL there are efforts underway to develop an AI application to assist in IT tech desk support. At SLAC, there are efforts underway to use an AI application to assist with requirements management. LBNL is exploring the use of AI in the assessment of activities relative to the risk matrix. National labs have similar operational challenges that can benefit from sharing templated design frameworks for the GenAI applications and lessons learned throughout the GenAI application development and execution.

Another challenge in implementing GenAI to enhance operational effectiveness is the capability of siloed laboratory teams with limited resources to identify and eliminate barriers that threaten GenAI projects. Existing projects across the complex have challenges with access to data authorization and approval to use commercial AI models.

### Proposal

We recommend the formation of a cross-laboratory, multidisciplinary community of practice to develop guiding principles about use of GenAI, share lessons learned, and coordinate and steward GenAI use cases that could benefit the entire complex. This group should consist of experts spanning various domains, including operations, computer science, information management, security, policy, and ethics. Their collective knowledge and skills will be crucial in shaping the decision framework for the National Labs to optimize investment in GenAI projects. The team can anticipate the challenges associated with use of GenAI and provide options to mitigate them, so the projects have a greater chance of success. Typical challenges associated with the use of GenAI are found in Appendix E.

Additionally, there is a wide range of policies and experience using GenAI across the National Laboratories, and the complex will benefit from the sharing of best practices and experience. A coordinated community of practice can also reduce risk and confusion concerning guidance and policies related to use of GenAI. The CoP can provide a framework that generates consistency and trust in the use of GenAI across the complex to optimize operational efficiency and effectiveness.
This team could be charged to:

**Develop and Disseminate GenAI Guiding Principles.** Establish a set of guiding principles that outline the ethical, safety, and societal considerations that should underpin the development and deployment of GenAI technologies within National Lab operations. We recommend leveraging resources such as the *"DOE Generative Artificial Intelligence Reference Guide*" to support development of these principles. The *DOE Generative AI Reference Guide* provides guiding principles related to the safe and effective use of GenAI. It provides definitions, reviews the key risks and benefits, and provides common sense mitigations to reduce those risks. It highlights best practices and provides a checklist of items to consider when using GenAI. We propose to partner with the DOE Tiger Team to develop a short informative and educational multimedia communication of these guiding principles to share with all NL staff.

**Develop a Risk-Based Decision-Making Framework.** Build a framework to aid in evaluating potential risks associated with GenAI applications for operations, enabling informed decisions on implementation.

**Share Best Practices and Lessons Learned.** Capture lessons learned from deploying GenAI operations applications. Share these valuable insights throughout the DOE-Lab Complex. We recommend drawing on the recent experiences and lessons learned by the NL COO working group as they tried to implement a GenAI use case for operations at the DOE complex level.

**Create a Process for Implementing GenAI Operations Applications.** Provide a standardized approach and framework for designing, building, and deploying GenAI operations applications. This will expedite the creation of safe and effective GenAI operations solutions.
The insights and recommendations from the team could be used to inform DOE enterprise guidance and policy related to GenAI in operations, assuring alignment with the broader objectives of the Department of Energy.

The team could prioritize and sponsor the development of high impact cross-laboratory use cases. We have included three examples of potential high impact GenAI applications that could be designed, built, and used across the DOE National Lab Complex (Appendix C).

There is also a recognition that not all challenges will be solved using GenAI. Regular workshops that bring together the National Laboratory Operations and AI communities to assess high value areas in operations where GenAI could have a high impact should be a high priority for the team. Some of the promising general use cases for both AI and GenAI within the Lab Complex include:

**Development of AI-Driven Decision Support Systems.** Create intelligent decision-support systems that can assist scientists and researchers in formulating hypotheses, designing experiments, and interpreting results. These systems could use machine learning algorithms to analyze past and current research data, thereby suggesting the most promising avenues for future research.

**Automated Data Integration and Analysis.** Employ AI algorithms for the seamless integration and analysis of multidisciplinary data. This would simplify the often-complicated process of data collation from various domains, enabling researchers to draw more timely, accurate, and comprehensive conclusions.

**Optimization of Resource Allocation.** Utilize AI to analyze resource usage patterns within the labs and recommend optimal allocation strategies. This could reduce operational costs and expedite project timelines.

**Real-Time Monitoring and Predictive Maintenance.** Implement AI tools that can predict equipment failures and suggest preemptive maintenance schedules. This would reduce downtime and extend the lifespan of costly scientific instruments.

**AI-Enhanced Cybersecurity Measures.** As the labs handle sensitive and classified information, deploying AI-powered cybersecurity measures would provide an additional layer of protection against increasingly sophisticated cyber threats.

It is important to note that many DOE programs have begun investigating Large Language Models as a GenAI technology to assist with software development, including automated development of code and translation of code base from one language to another (e.g. Fortran to C++ conversion). This application of GenAI is cross-cutting between operations and research because software development is often its own research effort. Additionally, much of the other research undertaken at DOE laboratories requires significant investment in software development. Applying GenAI techniques to this area is a potential force multiplier in completing this job more quickly. However, DOE is required to demonstrate software quality and cyber assurance of all software generated for the various missions. This particular cross-cutting opportunity is a potential topic for the multidisciplinary CoP to investigate and share information across the labs.

To support this recommendation, we have collected information on the GenAI policies, guidance, and individual Lab use cases across all 17 DOE National Labs. This information provides insights into areas for potential collaboration and sharing of best practices. We used the questions found in Appendix A to collect the information via the CIOs and designated POCs for AI at each National Lab. The data were analyzed to characterize current initiatives, guidance, policies, and coordination across the laboratories. Additionally, the use cases input was analyzed to stratify use cases into logical categories, identify scopes of influence, and evaluate the extent to which similarities exist among use cases at various labs. The results are included in Appendix B.

## Appendix A. Questions Used to Collect Information on AI Efforts at National Labs

1. Name, title, and lab affiliation of interviewee.
2. Are you currently coordinating AI activities across the lab?
3. Is there a single person responsible for coordinating Generative AI activities?
4. What is the name, title/role, and contact info for the individual responsible for coordinating Generative AI activities.
5. Are you okay with us following up with this person?
6. Do you currently have any coordinated efforts to provide guidance to laboratory staff for Generative AI use in Research?
7. Do you currently have any coordinated efforts to provide guidance to laboratory staff for Generative AI use in Operations?
8. Do you have a policy regarding the use of Open Generative AI products (e.g. GPT 3.5, DALL-E) for lab sponsored work?
9. If so, what is it?
10. If not, do you plan to have one?
11. Does your lab IT policy allow for any Generative AI tools to be used on lab computers and networks? If so, can you share any details about your policy?
12. Do you have a defined process to review Generative AI research projects on the scientific side? E.g., LDRD, DOE and other agency proposal calls.
13. How do you assess the Technical, Ethical, and Information Security aspects of the Generative AI portions of the research.
14. What guidance is provided to groups developing Generative AI to ensure consistent, reliable, and trustworthy solutions (guidelines, policies, procedures, rules, etc)?
15. Is there a standardized approach for proposing Generative AI projects and identifying needed resources, timelines, projected cost, group composition, etc.?
16. Are there currently any Generative AI initiatives within the operations space at your laboratory?
17. Please describe the operations use case(s) under development, their expected development timeline, and their current state in the development lifecycle.
18. Please describe the group(s) charged with developing the operations use case(s), including their size, composition and, if possible, a point of contact for further information.
19. Who are you coordinating with external to the lab on Generative AI?
20. Identify other groups with whom you're collaborating, and the nature of the collaboration.
21. Do you regularly monitor for developing Generative AI initiatives to identify further opportunities to collaborate and/or coordinate?
22. How are you sharing guidance from DOE and other sources with your laboratory staff?
23. Do you have recommendations on how the National Labs could/should manage the use of Generative AI within the DOE-Lab Complex?
24. Do you have feedback on our think piece recommendations?
25. Are there any other contacts at your laboratory we should talk to about Generative AI in Operations?

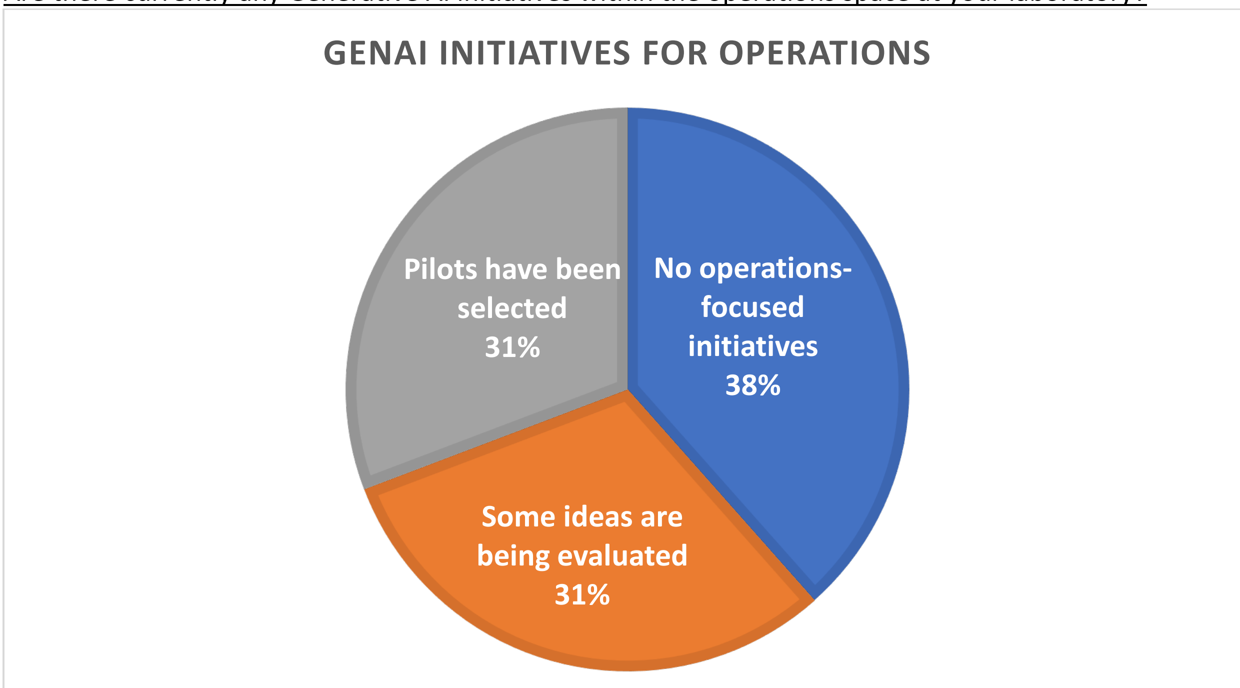
## Appendix B. National Laboratory GenAI Landscape

The team spoke to individuals from each of the 17 national labs to gather information on the GenAI initiatives, policies, guidance, and use cases. The majority of individuals who provided input were Laboratory CIOs, with some respondents being laboratory leads for AI initiatives. The questions used to gather this information are presented in appendix A. This appendix presents the results in two sections. The first section summarizes the responses to questions about policies, guidance, coordination, and initiatives associated with GenAI. The second section summarizes the use cases.

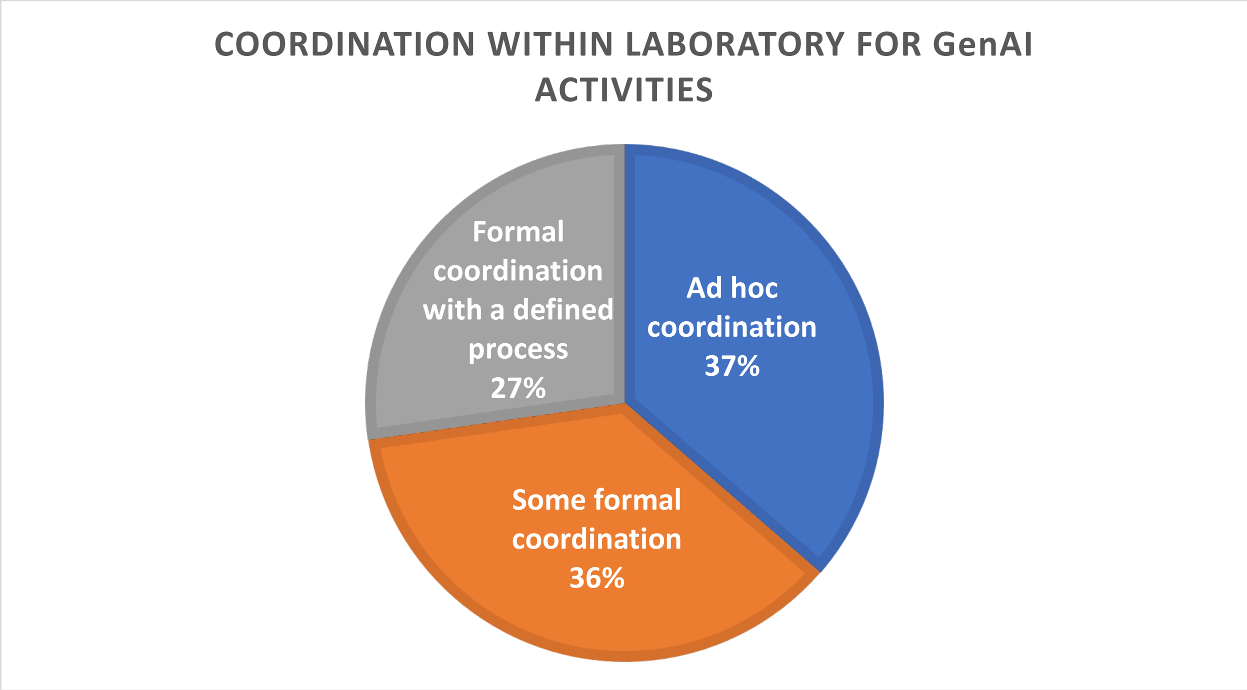
### Initiatives, Coordination, Policy, and Guidance

Based on the responses provided, a member of the team developed a coding scheme to bin the responses into a few categories. Some individuals did not provide an answer to all questions, the overall number of responses (hence the percentages) may vary. Some of the responses to multiple questions were collapsed into a single response category, which is described below when relevant. The responses are summarized below and organized by the question posed.

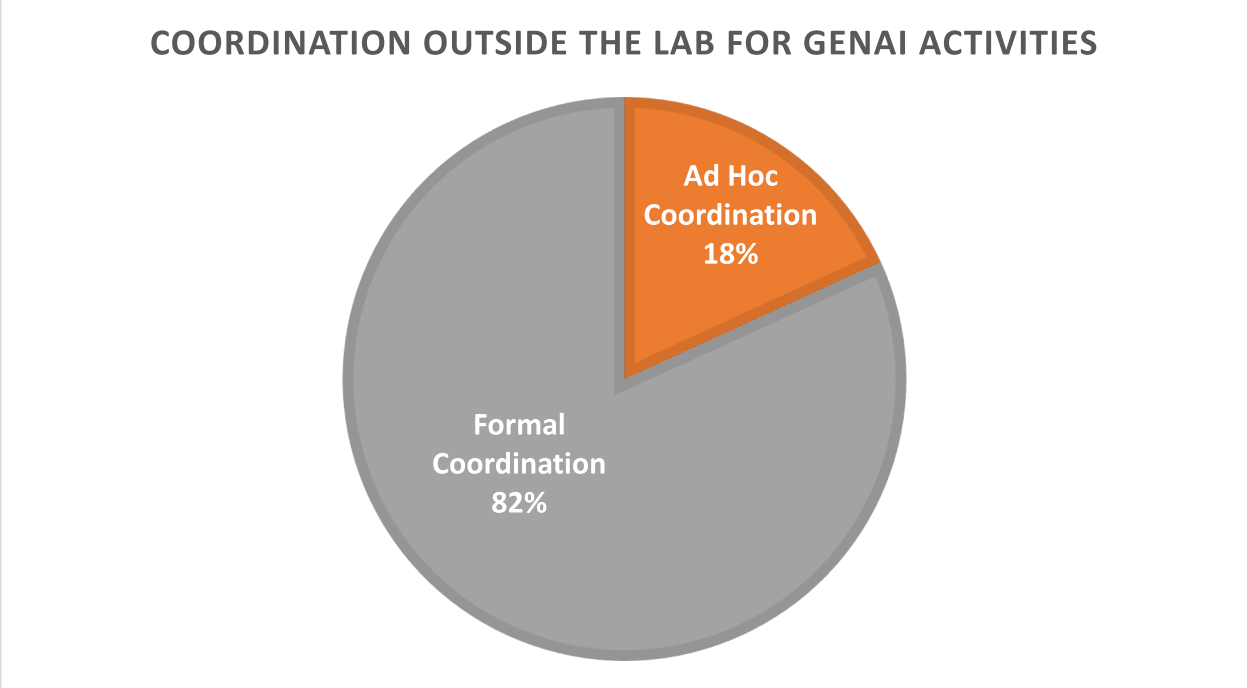
Are there currently any Generative AI initiatives within the operations space at your laboratory?



Are you currently coordinating AI activities across the lab?



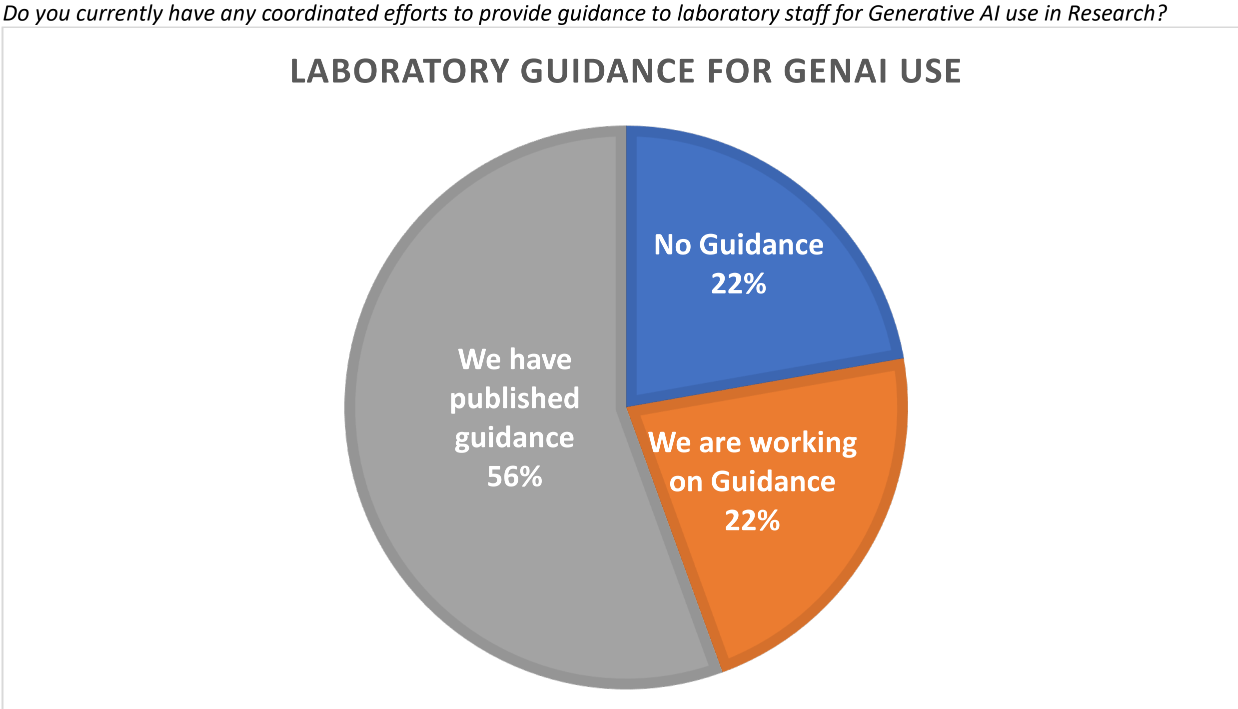

Who are you coordinating with external to the lab on Generative AI?
Note: responses to this question were combined with *Identify other groups with whom you're collaborating, and the nature of the collaboration.*



Do you currently have any coordinated efforts to provide guidance to laboratory staff for Generative AI use in Operations?

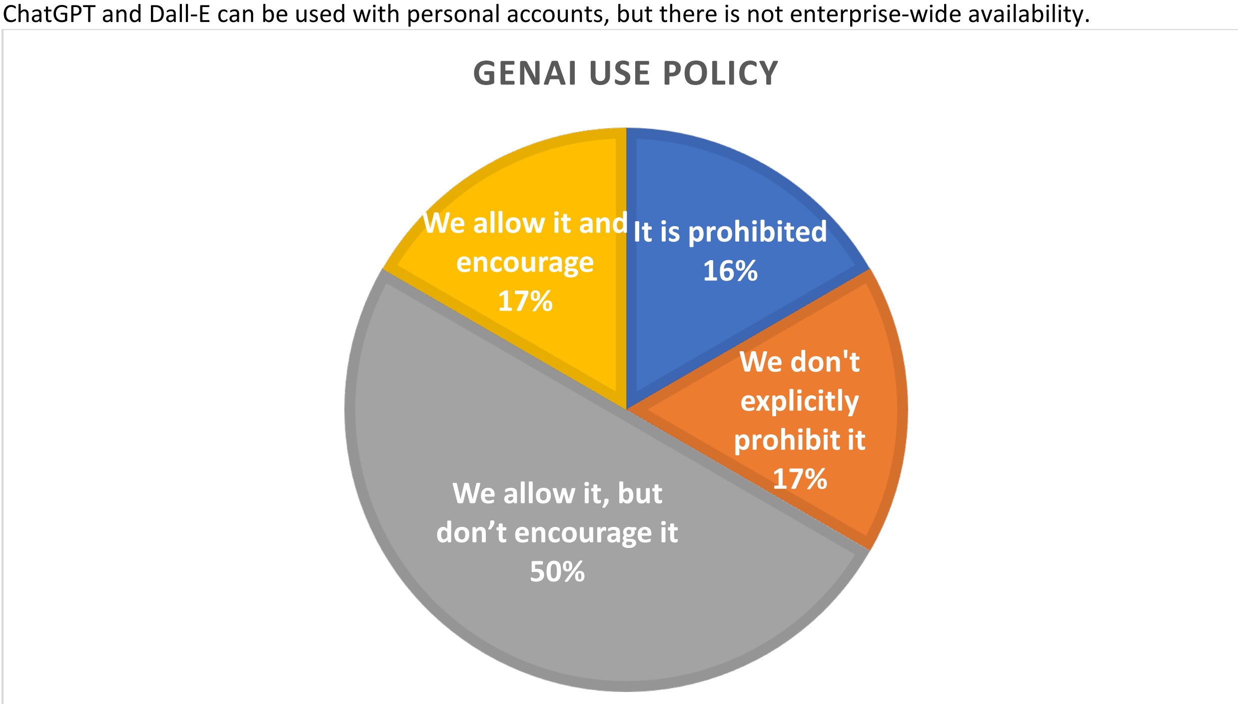
Note: this question was combined with the question about research (below) because all the responses were the same for research and operations.

*Do you currently have any coordinated efforts to provide guidance to laboratory staff for Generative AI use in Research?*



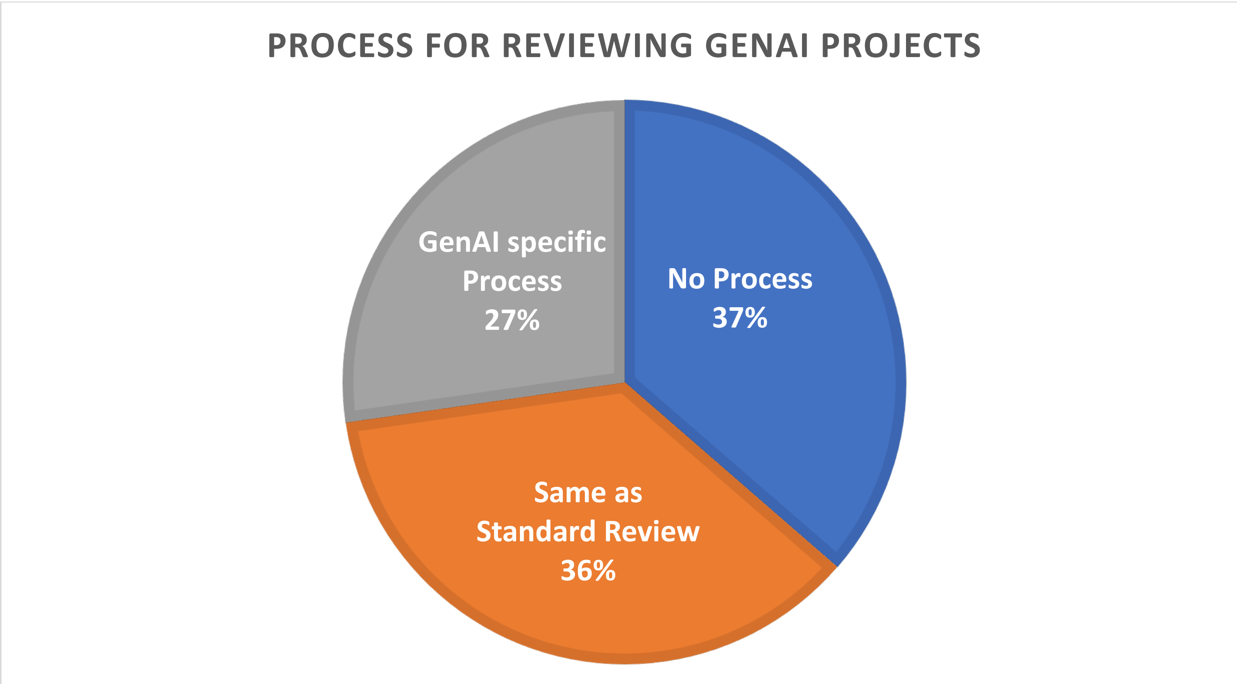

Does your lab IT policy allow for any Generative AI tools to be used on lab computers and networks? If so, can you share any details about your policy?

Note that only one lab stated they have authorization to operate specific AI tools. Most of the open tools such as ChatGPT and Dall-E can be used with personal accounts, but there is not enterprise-wide availability.

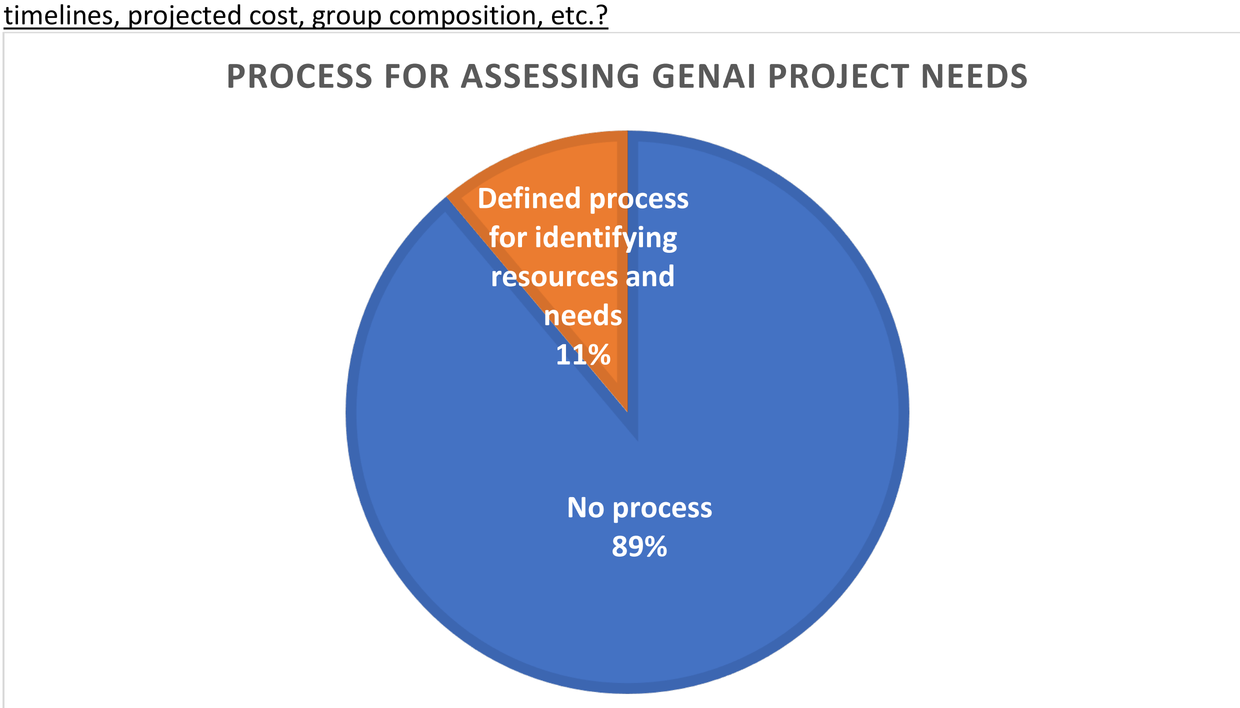


Do you have a defined process to review Generative AI research projects on the scientific side? E.g., LDRD, DOE and other agency proposal calls?

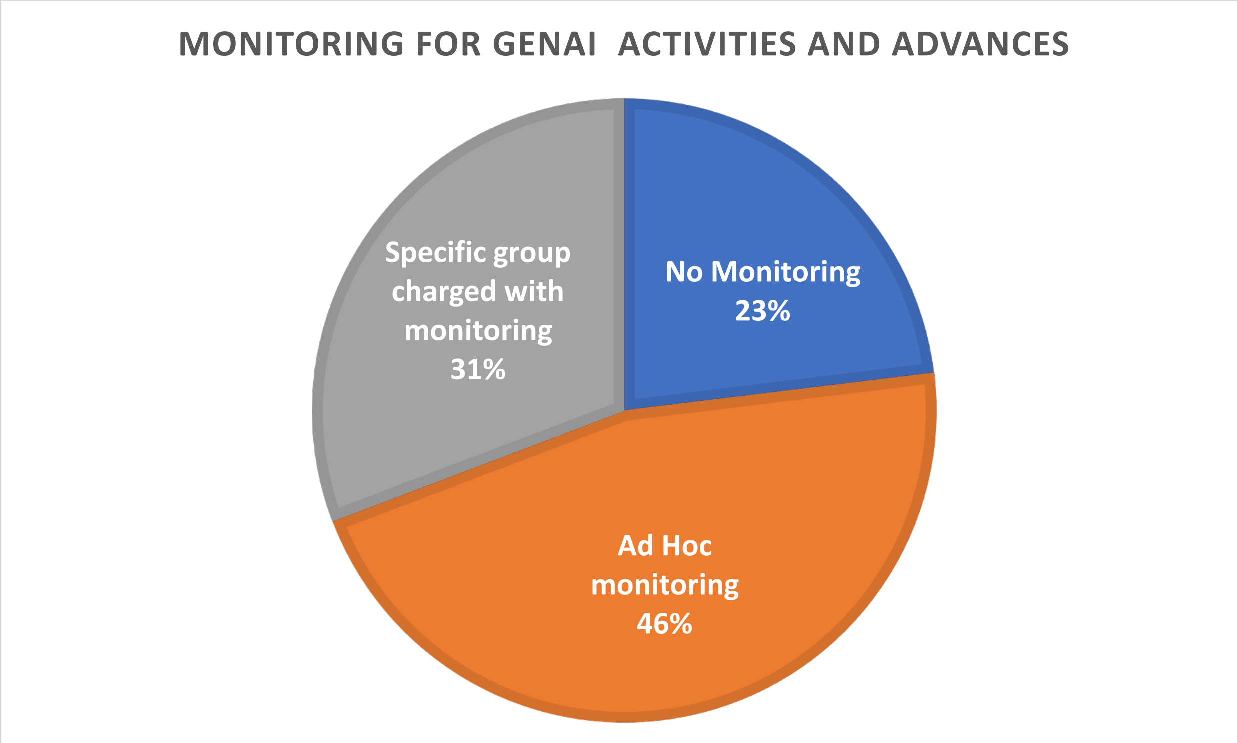
Note: this question was combined with *How do you assess the Technical, Ethical, and Information Security aspects of the Generative AI portions of the research?* Because the responses were similar.




Is there a standardized approach for proposing Generative AI projects and identifying needed resources, timelines, projected cost, group composition, etc.?



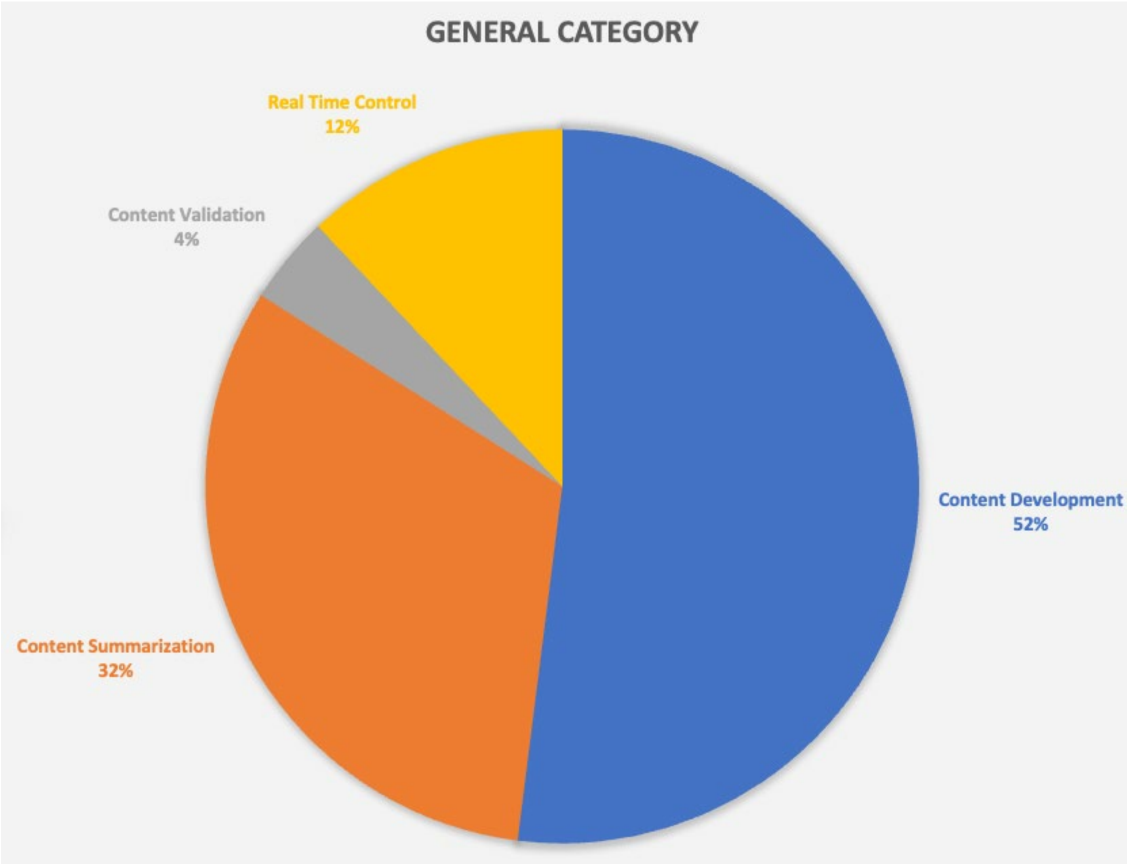
Do you regularly monitor for developing Generative AI initiatives to identify further opportunities to collaborate and/or coordinate?

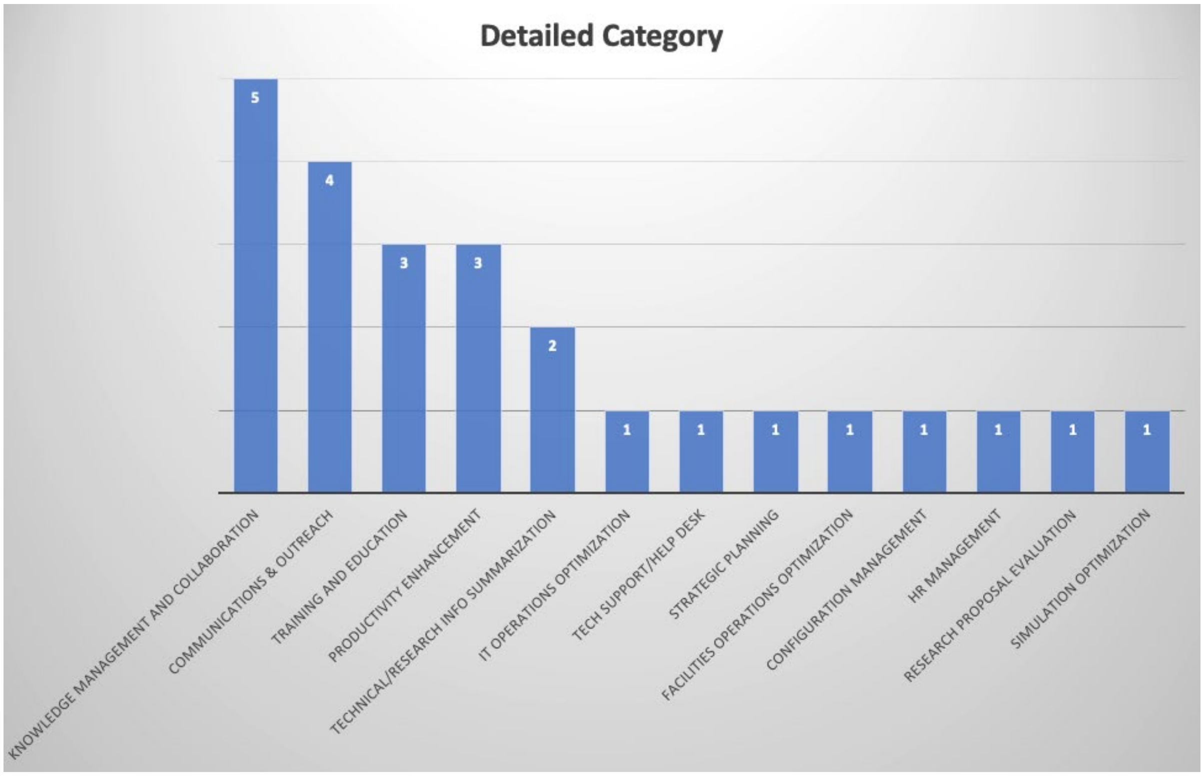



### Individual Lab Use Case Summary

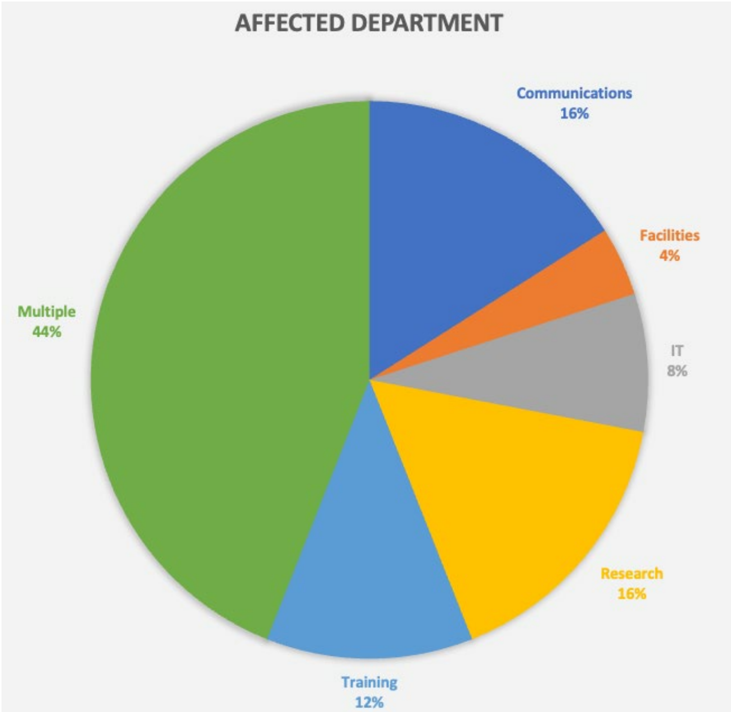
The data collected on existing and developing use cases across the NL Complex was analyzed to categorize the use cases, identify their scope of effect, and understand the degree to which commonalities exist between use cases. A total of 25 use cases were described and a summary of the analysis results is provided in the following charts.

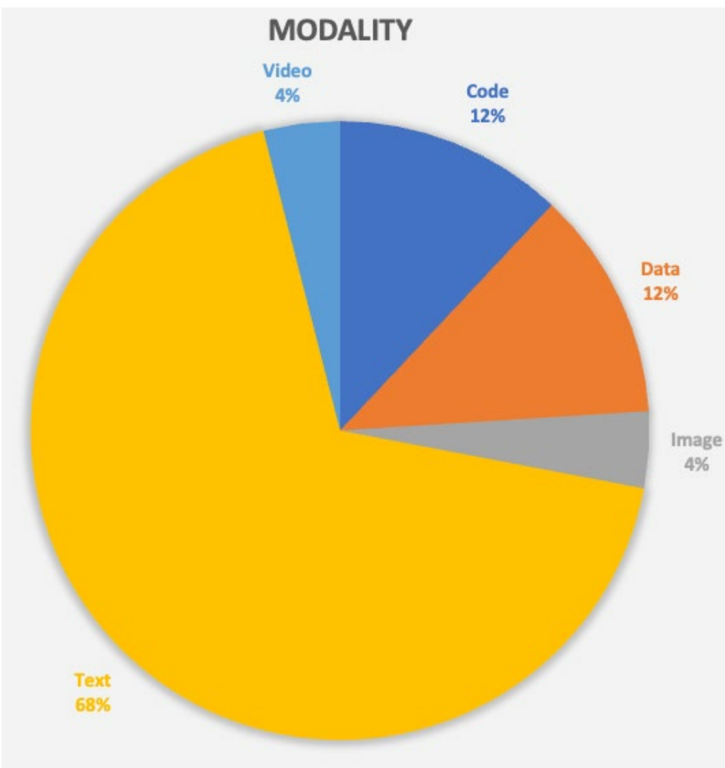
Use Case Category. The use cases were categorized to stratify cases by those which generate new content (Content Development), summarize existing content for ease of consumption (Content Summarization), provide content validation against a set of criteria (Content Validation), and support real time control of systems and/or infrastructure (Real Time Control). The data were further categorized into detailed categories to provide an understanding of the specific applications.

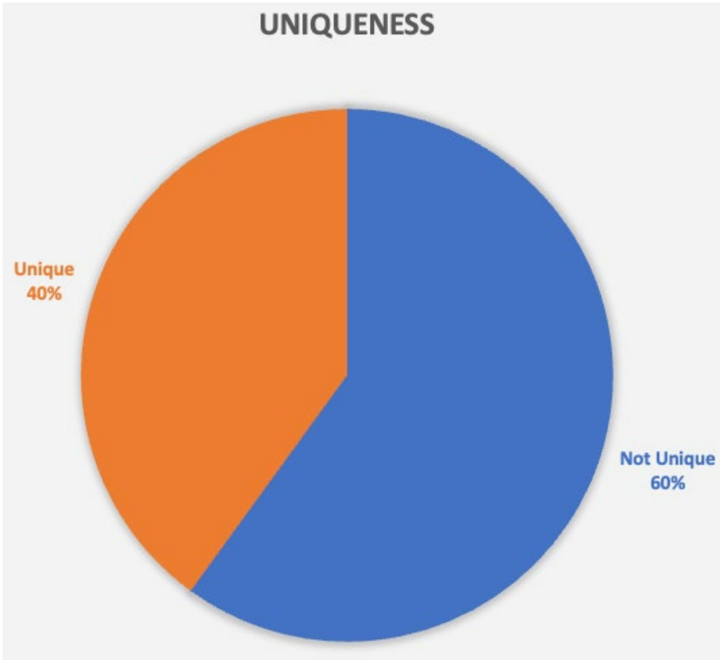

GENERAL CATEGORY
Real Time Control
12%
Content Validation
4%
Content Development
52%
Content Summarization
32%


Detailed Category
5
4
3
3
2
1
1
1
1
1
1
1
1
KNOWLEDGE MANAGEMENT AND COLLABORATION
COMMUNICATIONS & OUTREACH
TRAINING AND EDUCATION
PRODUCTIVITY ENHANCEMENT
TECHNICAL/RESEARCH INFO SUMMARIZATION
IT OPERATIONS OPTIMIZATION
TECH SUPPORT/HELP DESK
STRATEGIC PLANNING
FACILITIES OPERATIONS OPTIMIZATION
CONFIGURATION MANAGEMENT
HR MANAGEMENT
RESEARCH PROPOSAL EVALUATION
SIMULATION OPTIMIZATION

Scope, Modality, and Uniqueness: The use cases were further analyzed to identify their scope of effect (single department benefit vs multi-department benefit), the type of content they generate or operate on (modality – text, image, etc.), and whether they are significantly similar in nature to other communicated use cases or represent unique solutions.


AFFECTED DEPARTMENT
Communications 16%
Facilities 4%
IT 8%
Research 16%
Training 12%
Multiple 44%


MODALITY
Video 4%
Code 12%
Data 12%
Image 4%
Text 68%


UNIQUENESS
Unique
40%
Not Unique
60%

## Appendix C. Example Use Cases

### Example Use Case 1. AI-Driven Predictive Maintenance for Scientific Equipment at a National Lab

#### Objective

To achieve operational excellence by reducing equipment downtime, improving reliability, and maximizing utilization through AI-driven predictive maintenance.

#### Background

National Laboratories play a pivotal role in advancing scientific knowledge and innovation, housing complex and highly specialized scientific equipment essential for cutting-edge research. This equipment includes particle accelerators, which are used to study the fundamental properties of matter by accelerating subatomic particles to high speeds and observing their collisions; mass spectrometers, which allow scientists to analyze the composition of various substances at a molecular level; and supercomputers, which are critical for processing vast amounts of data, running complex simulations, and solving intricate computational problems that are beyond the capability of standard computers.

The efficient operation of these devices is crucial for the progress of numerous research areas of national importance. Particle accelerators, for instance, are fundamental in physics research and have applications in medicine and engineering. Mass spectrometers play a vital role in fields ranging from chemistry and biology to environmental science and pharmacology, enabling precise analysis that underpins significant scientific discoveries. Supercomputers, with their immense processing power, are indispensable in areas such as climate modeling, genomic analysis, and space exploration.

Consequently, the unexpected downtime of these devices can have far-reaching adverse impact. Research projects can face significant delays, disrupting the meticulous planning and coordination that goes into scientific experimentation and analysis. This not only hampers the progress of scientific discovery but can also lead to substantial financial losses. The costs associated with repairing and maintaining such sophisticated equipment are high, and any period of inactivity can mean a waste of valuable resources.
Moreover, these delays and disruptions can impair the laboratory's ability to fulfill its national obligations. National Labs often undertake research that is critical to national security, energy sustainability, and technological advancement. Any setback in their research capabilities can have implications for the country's scientific leadership and preparedness in addressing global challenges. Therefore, ensuring the reliability and continuous operation of the equipment in National Labs is not just a matter of scientific efficiency but also of national importance.

#### Stakeholders

Lab Managers
Engineers
Research Scientists
IT Department
Maintenance Teams
Funding Agencies
Federal Oversight Committees

### Current Scenario

- Maintenance activities are primarily reactive or scheduled based on manufacturer or design team recommendations.
- Unexpected breakdowns frequently interrupt mission-driven activities.
- Lack of real-time data on equipment conditions.
- High costs associated with emergency reactive maintenance and parts procurement.

### Proposed Solution

- Data Collection: Install Internet of Things (IoT) sensors on critical scientific equipment to collect real-time data on temperature, vibration, utilization, and other relevant metrics.
- Data Aggregation: Use a centralized data lake to aggregate data from different sources.

- AI Model Development: Train machine learning algorithms on this data and historical maintenance records to predict potential failures or performance degradation.
- Predictive Alerts: Implement an alert system that notifies maintenance teams of potential issues before they become critical failures.
- Dashboards: Create real-time dashboards for stakeholders to monitor the health of scientific equipment and ongoing maintenance activities.
- Automated Reporting: Generate automated monthly reports highlighting the performance and efficiency improvements, including potential cost savings.
- Compliance and Security: Ensure that the system adheres to national security standards and other compliance requirements.

### Expected Outcomes

- Reduction in unexpected equipment breakdown.
- Increase in equipment life span through timely maintenance.
- Decrease in operational costs by reducing emergency maintenance activities.
- Improved research output due to higher availability and reliability of scientific equipment.
- Data-driven decision-making capabilities for lab management.
- Reduction in the potential for ES&H incidents.
- Reduction in maintenance cost.

### Risk Assessment

- Data Security: Ensuring the confidentiality and integrity of data collected.
- Technology Adaptation: Training staff to adapt to new maintenance procedures and technologies.

### Conclusion

Implementing an AI-driven predictive maintenance system will significantly enhance the lab's operational excellence. By adopting this approach, the lab will save on maintenance costs and significantly improve its research capabilities, thereby fulfilling its mission-driven obligations with agility and more efficiently.

## Example Use Case 2. AI-Driven Sourcing and Tracking Supply Chain Inventory Procurement to Reduce Scope 3 GHG Emissions at National Laboratories

### Objective

Streamline carbon footprint analysis for supply chain sourcing and transport to achieve net zero emissions from federal procurement by 2050.

### Background

National Laboratories purchase a large diversity of products and equipment. However, while some purchases may be concentrated in specific providers, the purchasing power of the National Labs may result in a diffuse pool of sources, reducing the ability to influence supply chain manufacturers to produce carbon-free products and influence software company development for tracking product life-cycle Scope 3 Greenhouse Gas (GHG) emissions. Scope 3 GHG encompasses emissions that are the result of activities from assets not owned or controlled by the reporting organization, but that the organization indirectly affects in its value chain. The GHG Protocol defines 15 categories of scope 3 emissions, though not every category will be relevant to all organizations. From this associated list, the first four categories are relevant to this use case: purchased goods and services, capital goods, fuel and energy related activities, and upstream transportation and distribution. Because these sources are so broad and lack instrumentation for data collection, rigor, and fidelity, curating the database needed to create an AI library poses a great challenge. Other federal mandates directing Scope 1 and 2 emission reductions have a horizon goal of 2035. This can help the Scope 3 market as these other categories of Scope 1 and 2 will be the first reachable objectives for these companies. The Scope 1 emissions encompass their direct onsite emissions such as central plants or heating and cooling within their operational control. The Scope 2 emissions are associated with the electricity they purchase from their utility provider.

The President's Executive Order 14057 directs the federal government to use its scale and procurement power to achieve net-zero emissions from overall federal operations by 2050, including a 65 percent emissions reduction by 2030. So, this mandate could be a driver in markets for vendors to begin creating GHG profiles to track. Recent Rocky Mountain Institute studies ascertain that the average supply chain GHG emissions are 5.5 times higher than the direct emissions from an organization's own assets and operations. Therefore, more accurately measuring the organization's supply chain carbon impacts would provide visibility and incentive for better purchasing decisions to meet the intent of federal mandates. AI can assist in supply chain sourcing, purchasing, and transport to reduce Scope 3 GHG emissions for an organization operational footprint by providing real-time data on supplier manufacturing, performance, and carbon emissions. AI can also help optimize transportation routes to reduce fuel consumption and emissions for product delivery.

### Stakeholders

Sustainability Managers
Research Operations Managers
Building Engineers
Site Operations Project Managers
Procurement professionals

### Current Scenario

Insufficient product and logistics information available to inform low-carbon procurement for goods and services, construction materials, and research and operations equipment. National Laboratory procurement departments handle these mandates through the inclusion of contractual clauses, but implementation is not tracked or measured to verify these requirements are being met. The lack of industry standards and tools does not enable full accounting processes.

### Proposed Solution

Developing a procurement process workflow and identifying data collection categories are the first stages to address this problem.

Task 1: Optimizing the procurement process.

Collaborate with GSA current efforts for the Scope 3 community of practice with all federal agencies in aggregating buying power projections to forecast how budgetary dollars could be spent for the greatest GHG reduction. Provide input to their current high-level assessment and calculation methods.

Task 2: Increasing accuracy by identifying criteria to capture the biggest value of GHG reductions.

This criterion would provide the backbone for data collection for future AI analytics.

Task 3: Investigate software development partners for platform analytic creation that could potentially be utilized across all federal agency procurement. DOE could establish a pilot use case before wider adoption. This pilot could also investigate how standards can be created to catalyze a unified approach.

### Expected Outcomes

Establishing preliminary approaches to understanding the functions of the supply chain logistics can decipher where the value lies to achieving a deeper carbon accounting operational footprint. Furthermore, through this lens resilience and vulnerability impacts pertaining to materials and manufacturing can be revealed to understand earlier and redirect efforts for acquisition to fulfill scientific and operations missions.

### Risk Assessment

In assessing and influencing the DOE supply chain, gathering information on the direct supplier may not reach the actual manufacturer of a product (i.e. a supplier may not be the entity that actually creates the product). Tracking the full cycle of the supply chain is not transparent or easily achieved. So, it is critical to establish an approach where a boundary scope is written for each Scope 1 GHG emissions category of what will be identified and possible to include to get the entire life cycle. Digging deeper into the supply chain and direct sources of manufacturing is more difficult but provides a clearer picture of greenhouse impact and overall supply chain resilience. Without this in-depth look at providers, DOE may be under or overestimating the stability of the supply chain and the overall greenhouse impact of purchases.

### Conclusion

These initial steps recommended in catalyzing a solution are important to establish processes, standards and values for the elements within the supply chain. By the time more fidelity is brought to curating a data library GHG emissions derived from Scope 1 and 2 will be reduced, so by 2050 there will already be reduced emissions embedded in the supply chain.

## Example Use Case 3. AI-Assisted Acquisitions at the DOE National Labs for Optimized Use of Federal Dollars

### Background

The DOE National Labs have a combined annual operating cost of $17.5 billion (FY19). The laboratories' missions are best achieved with an efficient use of these dollars. Using the Department of Health and Human Services (DHHS) BuySmarter initiative as a model and the wealth of data that is already available at the laboratories, there are opportunities for the DOE laboratories to optimize their research and development expenditures. In response to Executive Memo M-17-22 tasking DHHS "to consider government-wide contracts for common goods and services to save money, avoid wasteful and redundant contracting actions, and free-up acquisition staff to accelerate procurements for high-priority mission work," DHHS started a BuySmarter initiative to modernize its $24 billion annual spending. BuySmarter is a "data-driven strategy...leveraging the power of artificial intelligence and e-commerce solutions to modernize the entire procurement experience." Working with the company NOLIJ Consulting, an AI tool was developed to compare 2 million contracts, schedules and public price lists to make acquisitions with lower pricing (e.g., comparing prices), better terms, and utilize economies of scale. Savings across DHSS are projected to be $720 million per year. The procurement process can be faster allowing personnel to focus on more mission critical work. The developed AI tool was used by DHHS during the COVID pandemic to overcome supply chain issues encountered in many sectors, making the agency more adept at achieving its mission.

### Stakeholders

Acquisitions Professionals
Budget and Finance Staff
All Staff who use Acquired Commodities

### Current Scenario

Generally, acquisitions are not coordinated across the National Lab complex, and perhaps not even within each National Lab. Yet, there is extensive data that is available at all the National Labs from prior acquisitions. The wealth of this information means it cannot be efficiently and collectively considered for each subsequent acquisition. The acquisitions process can be time consuming, is subject to many federal regulations, and may hinder the missions of the laboratories due to delays or supply chain problems.

### Proposed Solution

Use the DHHS BuySmater Playbook and the "Government Services Administration Multiple Award Schedule Contract" to acquire the AI tool from Nolij Consulting. Implement an initiative across the National Lab-complex similar to the DHHS BuySmarter Initiative, whereby labs participate in data sharing to build up the AI tool using all available non-classified procurement-related documents (contracts, schedules, historical acquisitions records). Generate training materials so that these tools can be used effectively across the National Lab complex. Much of the data needed to accomplish this use case is already available, albeit not necessarily in a format that can be directly used to generate the AI model. As the data are available, elements of Use Case 2 can be integrated directly into the AI tool to incorporate carbon footprint into purchasing decisions.

### Expected Outcomes

- Reduce personnel time to complete purchase and end-to-end procurement process.
- Monetary savings from data-driven AI-assisted decision making.
- Improved stewardship of federal resources with better terms and conditions.
- Reduce supply-chain issues.
- Savings directed to mission objectives.

### Risk Assessment

Success requires the laboratories to work together in sharing data; if using a commercial vendor to develop the AI tool, the labs have less control over the tool and its development and maintenance, which may make the complex very reliant on a particular vendor. A poorly developed or maintained AI tool could reduce efficiencies in acquisitions and waste resources. This may jeopardize buy-in from the stakeholders that implementing AI strategies will improve processes.

### Conclusion

The procurement process will be faster allowing acquisitions and research personnel to focus on more mission critical work. Monetary savings from acquisitions will allow the labs to more effectively use research and development dollars. The laboratories won't face some of the supply chain issues that were encountered during the pandemic and afterwards. The laboratories will be more prepared for mission accomplishment for current security needs and future times of crises.

## Appendix D. Acknowledgements

| Individual/Group | Purpose |
|---|---|
| **Mentor** – Charlie McMillan (LANL), Kevin Doran (OSELP), Sue Winters (OSELP), Sue Suh (OSELP), Marcey Hoover (OSELP) | Provide guidance and input on think piece |
| **DOE Task Force** – Tom Harper (PNNL); Gardy Rosius (DOE) | Discuss DOE GenAI Reference Guide; provide OSELP feedback to Tom/Gardy on the reference guide; receive feedback on think piece |
| **NLDC CCO Committee** – Leslie Krohn (ANL) | Discuss think piece recommendation and communication with NL staff |
| **NL COO Group** – Adam Stavola (JLAB), James Lively (INL), Jacque Tidwell (PNNL) | Discuss think piece recommendations |
| **POCS for Gen AI for Operations Survey** – Malachi Schram (TJNAF), Amber Boehnlein (TJNAF), Adam Stavola (TJNAF), Sandi Oswald (SRNL), Court Corley (PNNL), Jacque Tidwell (PNNL), Quentin Krielmann (PNNL), Jennifer Lohrbach (AMES), Danny Ascione (PPPL), Adam Stone (LBNL), Mark Dedlow (LBNL), John Elliott (LBNL), Jonathan Russell (SLAC), Marc Cohen (PPPL), James Lively (INL), Kelly Rose (NETL), Ray Grout (NREL), Kerstin Kleese Van Dam (BNL), Gabriel Perdue (Fermilab), Julie Maze (LANL), Leslie Krohn (ANL), Kevin Dixon (SNL), Balendra Sutharshan (ORNL) | Discuss answers to questions posed in Appendix A regarding current laboratory guidance and GenAI efforts associated with operations |
| **COO Representative for LOB** - Juan Alvarez (INL) | Discussion and Feedback on think piece |

## Appendix E. GenAI Challenges to Consider

Data Privacy and Security: High-impact AI applications often require large datasets that may contain sensitive or classified information. Ensuring the privacy and security of this data while making it accessible for AI training and deployment is a significant challenge.

Ethical Considerations: AI technologies can potentially be misused or lead to unintended consequences, such as biased decision-making. Addressing ethical concerns like fairness, transparency, and accountability is vital but challenging.

Technical Complexity: Building advanced AI algorithms capable of handling the intricate operations and scientific research activities in National Labs involves sophisticated machine learning models. These are complex to develop, train, and maintain.

Integration with Existing Systems: Many National Labs have legacy systems that are not designed to integrate easily with advanced AI technologies. Retrofitting these existing infrastructures to accommodate new AI applications can be challenging and costly.

Resource Allocation: Developing high-impact AI solutions requires significant investments in terms of hardware, software, and human expertise. Balancing these resource demands with existing projects and priorities is challenging.

Interdisciplinary Collaboration: High-impact AI applications in National Labs often require collaboration between domain experts, data scientists, and policymakers. Facilitating effective cross-disciplinary communication and collaboration can be challenging.

Scalability: While a proof-of-concept might work on a small scale, scaling the AI application to meet the demands of the entire National Laboratory complex is a daunting task that involves various logistical and technical hurdles.

Regulatory and Compliance Issues: Given that National Labs often work on government-funded projects, they are subject to a myriad of regulations. Ensuring that AI applications comply with all relevant laws and guidelines is a significant challenge.

Validation and Verification: Ensuring that the AI models are accurate and reliable for scientific research or operational use involves rigorous testing and validation, which is both time-consuming and resource intensive.

Skill Gap: There may be a lack of necessary skills and expertise within the existing workforce to develop, manage, and interpret AI applications. This necessitates extensive training or hiring of new talent, which can be challenging.

# Governance to Accelerate CLEAN Energy RD&D

Michelle Slovensky (NREL), Joe Stoffa (NETL), and Sibendu Som (ANL)

- *What: The National Labs have extraordinary signature capabilities that, when connected and more visible to each other, could further accelerate innovation in transforming clean energy.*
- *Why: Sustainable, scalable clean energy is an urgent challenge for our time, and we are eager to share progress and learnings with each other across the Complex (and with industry) in concrete ways and in real-time.*
- *How: Pilot the concept of a "virtual clean energy demonstration complex" that allows all National Labs and DOE to swiftly collaborate on the highest priority breakthroughs and to exhibit the most promising solutions for adoption and deployment.*

## Overview

This think-piece investigates the implementation of a virtual demonstration complex to rapidly advance technologies and adoption through an evolved governance structure and operational deployment, utilizing the real-world setting of National Lab campuses. The DOE National Labs are driving clean energy technology discovery, but acceleration for deployment, scalability and commercialization is critical for transforming the energy sector and mitigating climate change. The World Economic Forum estimates the global population forecast to rise to nine billion by 2040, and current climate challenges will only become amplified. For global communities there is deep uncertainty about the magnitude, timescale and precise location of climate impacts which compounds the challenge of making informed decisions and investment commitments on how to best respond. The public sector, engaged in stewardship to achieve community resilience and stability, is looking to the science and industry sector to innovate and produce solutions for the global clean energy transition.


In the *Net Zero by 2050*, International Energy Agency's (IEA) roadmap for the global energy sector, most $CO_2$ emissions reductions through 2030 are primarily achieved through technologies on the market today such as solar PV, wind, and electric vehicles. However, in 2050 almost half of the emissions reductions forecasted are not from technologies available in the market today. Innovation in hydrogen, CCUS (Carbon Capture Utilization and Storage), geothermal, bioenergy, and nuclear must be in development within this decade to bring to the market in time to meet consumption growth and avert the worst impact of climate change. The Intergovernmental Panel on Climate Change (IPCC) states today's overall investment in clean energy innovation is increasing, but only gradually – far too slowly to meet our challenges head on. DOE's 17 National Laboratories have DOE program success and global acknowledgement in establishing significant signature capabilities that can be aggregated and optimized. The National Laboratory complex has been originated to achieve such a monumental challenge and consequential delivery which can then lessen the variety of challenges utilities and the energy manufacturing industry faces in catalyzing innovation and deploying practicable solutions rapidly.

National Labs can individually utilize their campus footprints as technology proving grounds. Coordinating the many National Labs, partnered with emerging technologies in the private sector, as demonstration sites will address the significant gap on how to integrate technologies into complex operational environments. The goal is to unlock larger system solutions and contribute more innovation along the entire energy value chain. Addressing and quantifying the integration challenges and operational readiness can drive the maturity of the technology. In aggregation and coupled through an operational lens, National Labs collaborating on larger joint technology demonstrations offer greater deployment, scalability, and commercialization impacts. Enabling connected research test beds within the National Laboratory complex via DOE's Energy Science Network OSCAR on a shared architectural platform could enrich data collection for DOE's Artificial Intelligence libraries, accelerate the evolution through DOE's Technology Readiness Levels, bridge multiple DOE applied technology programs, and increase collaboration with industry partners. Aligned with the recent introduction of DOE Office of Technology Transitions and Office of Clean Energy Demonstrations' Commercial Adoption Readiness Assessment Tool (CARAT), the approach envisioned in this think-piece could further enable progress towards adoption readiness and help identify additional development viability criteria.

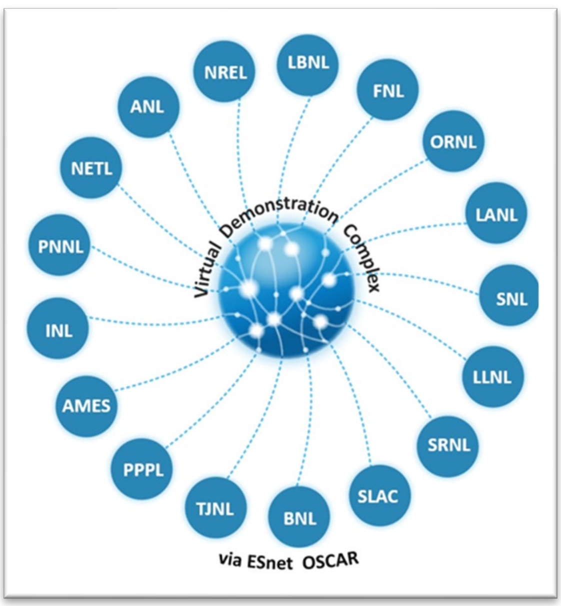



Fig 1: Proposed Virtual Demonstration Complex

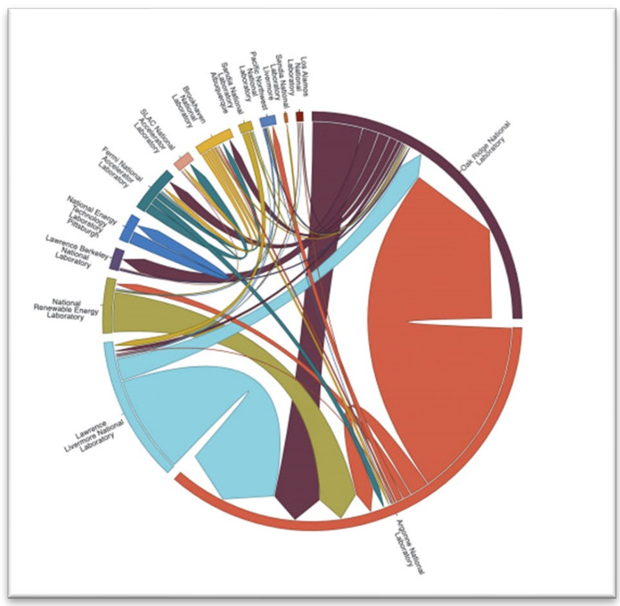



Fig 2: *Depicts the volume of data* moved across ESnet in 2022 between the top 40 pairs of national labs.*

For this initiative to be realized several critical actions are to be considered by the National Laboratory Directors Council (NLDC). Although signature capabilities exist at each lab, optimization of these resources can be delivered beyond singular intent. Capturing the benefit of their collective and unique use requires the establishment of a new group at each laboratory so that organizationally a team of subject matter experts can enable the creation, partnering and operation of this new virtual demonstration complex. This 'complex' will host a consortium to select initiatives to investigate a significant mission and energy transformation challenge, facilitate group exchange, collaborate internally to DOE program areas and externally with industry partners and academia. An approach to shaping a governance structure is considered below to establish the demonstration complex along with processes for the intake of mission program challenges. Lastly, for this initiative to be successful it necessitates an official and dedicated program sponsor within the DOE complex. As a starting point, the NLDC could support the hosting and facilitation of a workshop with DOE complex leadership to explore this conceptual idea into a tangible initiative.

**Process**

A) Cultivating the Concept

Our journey began with discussion amongst our cohort colleagues to elevate priority topic areas. From there our collective group was able to form synergies of thought around optimization, efficiency, human capital, and collaboration to enable our National Laboratory complex reach for greater achievements. Our trio translated these themes into the need for a virtual venue to connect the significant capabilities within the DOE complex and elevate for commercial maturity to decarbonize the global community. Over the course of the last 11 months, we have engaged with multiple advisors representing diverse perspectives. Through the investigation of this think piece, we obtained a deeper understanding of the DOE complex and the challenges it faces, but most importantly we sincerely enjoyed the journey to reflect on the possibilities.

- This mentorship ensemble included a DOE Field Office Director, S3 senior advisor, current executive vice president of multi-lab management and operations contractor, National Laboratory director, associate laboratory director, Energy Futures Initiatives Foundation author, several OSELP alumni, and senior National Laboratory research fellows.
- Each of these conversations delivered meaningful insight and support in evolving the concept. These discussions navigated and illuminated DOE organizational structures, interactions with other branches of government, congressional processes and appropriations, DOE program directives to the laboratories, technology readiness levels and adoption readiness levels for technology maturity and deployment, vulnerabilities for industry in bridging the gap from research to commercialization, funding sources and mechanisms, enhanced multi-lab collaboration and past consortium initiatives to highlight a few.

B) Discovery at National Laboratory Site Visits

From our visits to multiple National Labs, it was clear that collaborations between labs are prevalent for multiple large-scale problems of importance to the nation (some examples discussed below). It was also evident that labs have indeed developed complimentary expertise to support different program offices at DOE. Some examples of applied research driving fundamental research and vice versa were also seen. Vignettes about the use of large-scale user facilities that have changed our understanding of fundamental science and scientific discovery were inspiring. However, to accelerate the pace of innovation, it was clear that the National Laboratory complex needs to tighten collaboration, reduce overlap, and ensure that technologies developed have a clear path to commercialization to accelerate administration's decarbonization goals.

C) National Laboratory Models

Several models within the DOE system were investigated to understand how a virtual demonstration complex could learn from their successes and challenges to inform an example governance structure, processes, determine initiatives to pursue, integration and collaboration from multi-lab research expertise, hardware/software/network connectivity, program management, disbursement of funding and meeting DOE program objectives. These examples represent singularly focused efforts, and our challenge is to incorporate the value of each to create a more comprehensive ecosystem. Please see Appendix C for examples.

### D) Synergies with findings of Energy Futures Initiative

On November 8th, 2023, the Energy Futures Initiative (EFI) Foundation published a report on "Transforming the Energy Innovation Enterprise," which focuses on "Enhancing the Pace, Agility, Effectiveness, and Efficiency of the U.S. Department of Energy Management Structures and Processes." In this section we will highlight where a virtual demonstration complex could support structural changes proposed in the EFI report.

The EFI report highlights "moving the next generation of energy technologies more quickly through the innovation pipeline" (p. 12), and the virtual complex described in this white paper could directly address the recommendation to "establish a new technology-neutral fast track program to accelerate the mid-stage of the energy innovation process by funding the scale-up of promising technologies," though in the case of a virtual demonstration complex the initial stage of the "learn by doing" loop would occur virtually. The EFI report states that "such a program could be initiated as a pilot effort, depending upon the level of funding, and expanded as experience is gained."

With respect to maturing and commercializing technology, the EFI report makes a recommendation to "Expand National Laboratory test bed facilities to enable industry to test new technologies in a standardized setting, enabling industry to innovate faster and more efficiently," and that "This concept would expand upon the current evolving Lab-embedded partnership programs" (p.14) The virtual complex outlined in this think piece does fit this description, and could provide shorter timescale access to National Laboratory resources and expertise, representing a win-win scenario for public-private partnerships.

Finally, the EFI report recommends that "OCED should work with National Laboratories to establish teams of National Laboratory experts to provide independent science and engineering support for DOE-funded demonstration projects and capture the learning by doing from these projects to inform future DOE RD&D activities." (p. 39) A virtual demonstration complex would serve as a center of expertise for technology development and maturation, including analysis functions such as lifecycle analysis, techno-economic analysis, and market analysis.

### E) Capturing Value through Use Case Examples

The success for maturing the evolution and application scale of clean energy technologies requires assessing its role and performance within different ecosystem deployment scenarios. We have identified two use case scales where technological development correlates directly with its spatial scale of use. The virtual demonstration complex can evaluate early TRL to reconcile its potential and viability in order to proceed with future stages of development. The gap from late TRL to commercial viability for market adoption surfaces many vulnerabilities that can be a tipping point to limiting its introduction and longevity. Increasing opportunities for deeper assessment in operational settings can reveal interoperability challenges thereby de-risking its deployment path. Please see Appendix B for examples.

### Challenges

A) Optimize Integration Between DOE Branch Offices

The DOE complex encompasses capable professionals dedicated to the implementation of DOE's prime directives and White House administrative objectives. DOE's current organizational structure can support current administrative and congressional objectives but to enable the audacious challenges to national security and the clean energy transformation a shift towards creating fluidity between the branch offices is critical. As historically demonstrated by past events to end WWll and most recently address the key challenges in responding the COVID-19 threat a DOE Team Science approach is essential to achieve scientific breakthroughs that would not be attainable simply by additive efforts.


Considering current branch office functions some actions could be taken to optimize outcomes. Creating a symbiotic relationship between directorates can catalyze action and remove current barriers. For instance, the S3 office, recently established with new authority, needs to utilize mission areas within the S4 office for successful deployment to fulfill Congressional IRA funding implementation. The S4 office has program capabilities to develop mission science but needs to support leveraging for deployment to bridge the maturity gap so industry partners can accelerate commercialization. If silos of excellence continue to remain stove-piped then advances are handicapped. Processes outside the DOE organizational structure also hamper advancement. Modifications for the execution of funding mechanisms and oversight can unlock opportunities for creativity and remove existing territorial behavior. Additionally, DOE can enhance working relationships so OMB can widen their perspective and evaluation.

B) Optimize Processes to Overcome Current Administrative and Funding Challenges

DOE support of RD&D can produce an impact when technologies can be commercialized within the time and budgetary constraints of their supporting program. While technical viability, economic attractiveness, and environmental benefit are pre-requisites for successful deployment, they do not guarantee it. Under optimal conditions, National Laboratories provide an opportunity to decrease both the time and private-sector budget necessary to reach commercialization when strategically combined with other RD&D mechanisms. These temporal and budgetary advantages, as enabled within the context of a virtual demonstration complex, will be explored below.

1) RD&D timelines

- Progress can be modeled as the advancement made during one iteration (an individual project) multiplied by the number of iterations (unique projects executed).
- If serial in nature, the pace of innovation is limited by how quickly an RD&D effort can identify the critical unknowns, develop a scope, or work to address the unknowns, and execute that scope of work.
- National Laboratories have an inherent “pace of innovation” advantage from their capability to turn program funds into RD&D via Field Work Proposals on the timescale of months, whereas turning program funds into extramural RD&D requires twelve to eighteen months through vehicles such as financial assistance.
- For mid-level technology readiness levels (TRL) RD&D, this advantage would be multiplied by a virtual demonstration complex as early operational data, digital twins, grid simulation, and off nominal scenarios could be simulated earlier in the technology development cycle, allowing a program to determine which questions need more quickly answered. There are always issues discovered at the engineering and pilot scale when a technology is tested on non-idealized process streams and connected to balance of plant equipment subject to failure, off-nominal operation, and unexpected external upsets. It is envisioned that some of these issues could be identified upon testing in a virtual venue, enabling more mature engineering and pilot scale testing, which could significantly reduce a commercialization timeline as compared to physical testing with conventional grants and cooperative agreements.

2) Programmatic perspective

- National Laboratories can be more cost-effective than private-sector recipients of grants and cooperative agreements under some conditions (even excluding the time-value of money point raised previously). Due to the nature of the funding opportunity announcement evaluation and selection process, it is often necessary to select multiple recipients to increase the probabilities of a successful RD&D outcome or it is necessary to select recipients that must develop a competency or tool they currently lack. In the context of a virtual demonstration complex, the capability to direct RD&D with a known entity that has demonstrated the tools and competence necessary to execute the project alleviates some of these concerns.
- A virtual complex is particularly attractive when combined with the techno-economic analysis (TEA) and lifecycle analysis (LCA) expertise present within the National Lab system, as this synergy allows for independent economic and environmental impact data, allowing programs to more quickly determine whether the expected economic and environmental benefits of a particular technology remain positive as scale increases. Having this knowledge earlier in the RD&D timeline provides programs with more options to either adjust programmatic goals or reorder programmatic priorities prior to engineering or pilot scale tests.

## Recommendations

We have shaped our recommendations in response to the considerations investigated and identified in the pursuit of grounding our conceptual idea into a tangible initiative. We present three aspects to further its feasibility and action with DOE.

### A) Exploring a Governance Structure for the Virtual Demonstration Complex

Throughout the National Laboratory complex successful multi-lab collaborations are occurring to meet clean energy transformation challenges but they conclude and future efforts to replicate and aggregate are absent. There are several consortiums established that link multiple project efforts around a singularly focused DOE program but are functioning for a set timeline. For each of these instances different organizational structures are defined and the speed to launch each new venture has slow traction. In many DOE FOAs efforts are always emphasized for research teams to replicate and scale efforts across the complex to increase efficiency, productivity, and delivery value. But these are collections of projects that are not creating a venue where the pipeline is repeatable with scalable results. Exploring the establishment of a Virtual Demonstration Complex could provide DOE with this mechanism.

This will require thoughtful consideration in forming a governance structure that is program agnostic, enables bridging DOE Complex challenges, spans multiple mission sectors, conducts efficient processes for the use of signature assets, and accelerates the awarding and conducting of the work. The importance of this governance structure will also safeguard that the decision-making processes remain structured, transparent, and focused on the objectives prioritized by a DOE advisory board and an industry council. This venue will also capture the ability to better deploy operational and process effectiveness and enhance project management and delivery. Upon reviewing current consortiums active within the DOE Complex, we offer an example framework that incorporates enhancements for DOE leadership to consider. Please see Appendix A for description of roles for this example framework.

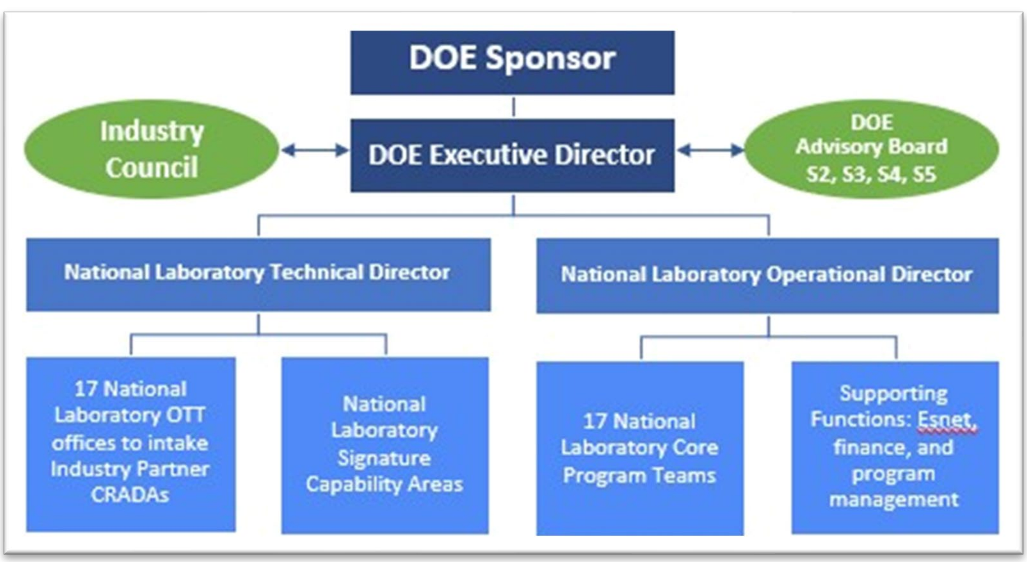



Fig 6: Example Framework for Governance Structure

B) Optimize Administrative, Timeline and Funding Processes

It is envisioned that a virtual demonstration complex could add several cycles of value along the pathway to commercialization, including at the engineering scale, pilot scale, and demonstration scale. The budget for demonstrations through some offices (e.g., OCED) is quite sizable, and even modest improvements in equipment layout/design and operating conditions could represent tens of millions in savings in addition to potential time savings.

A virtual demonstration complex allows:

- DOE to demonstrate the value of a particular technology or approach to the private sector, which could support the DOE perspectives that are relayed through such documents as the Pathways to Commercial Liftoff.
- DOE to better understand a recipient's constraints and limitations, which can inform a program on their influences and, if possible, address those concerns through RD&D or policy earlier in the developmental timeline.

A virtual demonstration complex could:

- encourage data sharing, as disparate participating offices may be delineated by fuel type (e.g. nuclear, renewables, fossil energy) but have interest in similar end uses (e.g. high temperature electrolysis or conversion of $CO_2$ into algae).
- improve the stove-piping of data that can occur under organizational paradigms.
- enable a combined data repository such that disparate data on related projects could inform programs that are not housed in the DOE office where the data was first created. This is especially timely in the need to create a complex data library to position DOE's achievement in the generative AI emerging capabilities.

C) Potential Mission Applications

As National Laboratories our collective directive is to address DOE's core mission in energy, science, national security, and environmental stewardship. Each of our laboratories contribute specific core competencies, unique facilities, and research teams representing an array of disciplines to push the boundaries of science, engineering, and technology. The virtual demonstration complex provides the venue for DOE to address the complex's most pressing challenges. Below we list priority categories DOE consider as a starting point to create a pilot to demonstrate proof of concept and ultimately have a mechanism for continued success in areas where performance must be expedited to uphold congressional commitments and appropriations funding timelines.

- Venue to accelerate the disbursement of congressional appropriation funds – The Bipartisan Infrastructure Law, the CHIPS & Science Act and Infrastructure Reinvestment Act have overlapping priorities and together introduce $2 trillion in new federal spending over the next ten years. The Office of Clean Energy Demonstration can use this virtual demonstration complex to accelerate awards for FOAs to conduct the research deployment and meet its congressional funding obligations within dictated timelines

- Energy Earthshots Initiative – accelerates breakthroughs of more abundant, affordable, and reliable clean energy solutions within the decade. Some of these initiatives could be ideal candidates to arrive at the solution points of the most challenging technical problems.
- Inventory of R&D ready for commercial partners to activate.

## D) Host and Facilitate a Workshop with DOE Office Leadership

Our think piece trio would like to evolve this concept into a tangible initiative beyond the presentation to the NLDC. We would like to receive approval from the NLDC to convene a working group to create a vision and agenda to facilitate a workshop with DOE leadership. This workshop venue can catalyze sharing and promotion of the virtual demonstration complex concept with DOE for the objective to bridge the four program offices objectives to enhance delivery impact. In addition to the three of us, this working group could include interested National Laboratory directors, OSELP alumni, key researchers from applied programs, OTT directors, research operation directors and DOE field directors. A suggested agenda could include five categories crucial to materializing the virtual demonstration complex.

- Governance Structure - explore a typology framework
- Mission Use Case - identify a working group for conducting a pilot
- Partnership Vehicle- create an umbrella CRADA
- Industry Access - socialize a patent R&D library
- Collaboration- apply a change management approach

We appreciate the NLDC's support in our professional development and dedicated time to review and consider our think piece concepts.

## APPENDIX A

Description of Roles for Governance Structure

### DOE Sponsor

The Secretary, Deputy Secretary, and Under Secretaries will determine which branch office will spearhead this new organizational program empowering the support, resources, and leadership authority to be successful.

### DOE Executive Director

DOE Sponsor's designated executive will direct, manage, and deliver the virtual demonstration complex activities according to the strategic direction of the DOE Advisory Board. This executive director will be advised by the Industry Council to inform the DOE Advisory Board of external drivers that influence or shape the needs for the transformation of a clean energy society. This individual will lead the culture and institutional climate to empower all individuals contributing to the organization. Responsible for communicating requests to DOE sponsor and managing funding resources for the program.

### DOE Advisory Board

Should comprise leadership from S2, S3, S4 and S5 offices to set priorities and determine mission challenges.

### Industry Council

A membership body composed of clean energy industry companies developing technologies to transform energy systems for a smarter, cleaner future. They inform the Executive Director of challenges and opportunities that are essential to clean energy manufacturing, industrial efficiency, decarbonization, scalable solutions, consumer adoption, policy development and growing the nation's clean energy economy.

### National Laboratory Technical Director

Oversees and coordinates the National Laboratories OTT directors and CRADA partners, aggregate signature capabilities and assets to define coordinated research activities for a given mission directive. Key personnel in assisting the Executive Director to administer procedures, roles and division of responsibilities for repeatable initiative delivery and objective success.

### National Laboratory Operational Director

Oversees and coordinates the core program teams represented by each National Laboratory to assemble a given mission directive. Responsible for consistency in program management execution, coordination with ESnet User Facility, and disbursement of funding resources. Key personnel in assisting the Executive Director to administer procedures, roles, and division of responsibilities for repeatable initiative delivery and objective success.

### National Laboratory OTT Offices

Works with industry candidates to create CRADAs that will fulfill given mission directives. Key stakeholders will bridge and nurture relationships to evolve TRL technologies for commercialization.

### National Laboratory Core Program Teams

This group is a hybrid of permanent staff comprising researchers, analysts, and mission operations subject matter expertise. These very capable individuals have a deep and broad command of diverse clean energy technology areas to represent the most proficient integrators. They will also disseminate peer-to-peer learning to catalyze deeper collaboration and increase knowledge gained amongst the 17 core program teams. Each core program team will have a lead representative for the identification of personnel, characterization and promotion of capabilities, tools, technical resources, and strategic interests for each lab's participation.

**APPENDIX B**
Capturing Value Through Use Case Examples

### 1) Exploring solutions for Sustainable Aviation Fuel:

DOE together with other agencies has released the SAF grand challenge which is primarily focused on SAF production and scale-up. SAFs are critical for decarbonizing the aviation sector. Multiple labs together with partner agencies like FAA, NASA, etc., have critical expertise towards ensuring that sufficient testing is performed so that certified SAF adoption can be de-risked. The Technology scale investigates the evolution of bringing a product to a market sector. The picture below illustrates an array of National Laboratory signature capabilities and fellow federal agencies that are investigating different development stages critical for the delivery of SAFs.

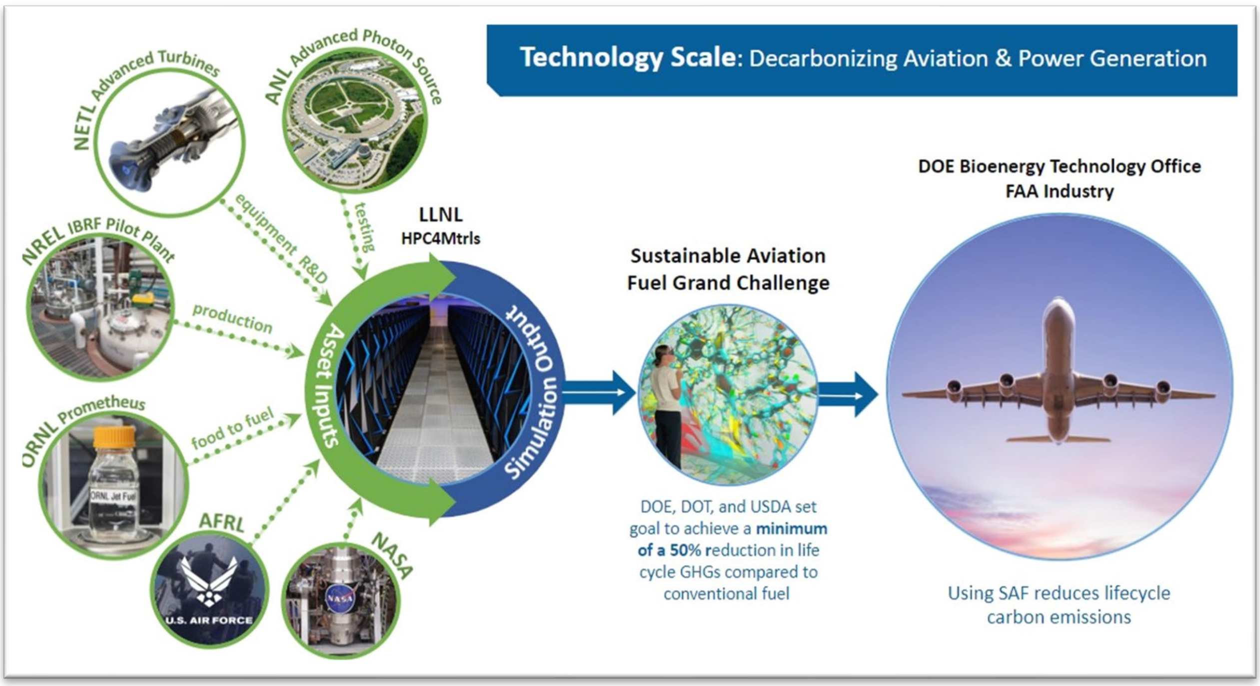



Fig 3: Ideation through production can be investigated in this virtual environment

### 2) Exploring solutions for Direct Carbon Capture (DAC):

Because DAC is intended to remove already emitted $CO_2$ from the atmosphere it can be deployed anywhere. However, driving technology maturity for DAC may not just be about the singular purpose in the development of equipment. Enabling more synergistic and effective research advancement interaction with other environmental inputs could drive a different approach outside the typical research laboratory. Investigating how DAC could function within the built environment necessitates more diverse inputs that influence technology maturity. Incorporating more sensored data representative to a multitude of interoperability processes can increase our understanding of their functional and performance contribution to create system level responses.

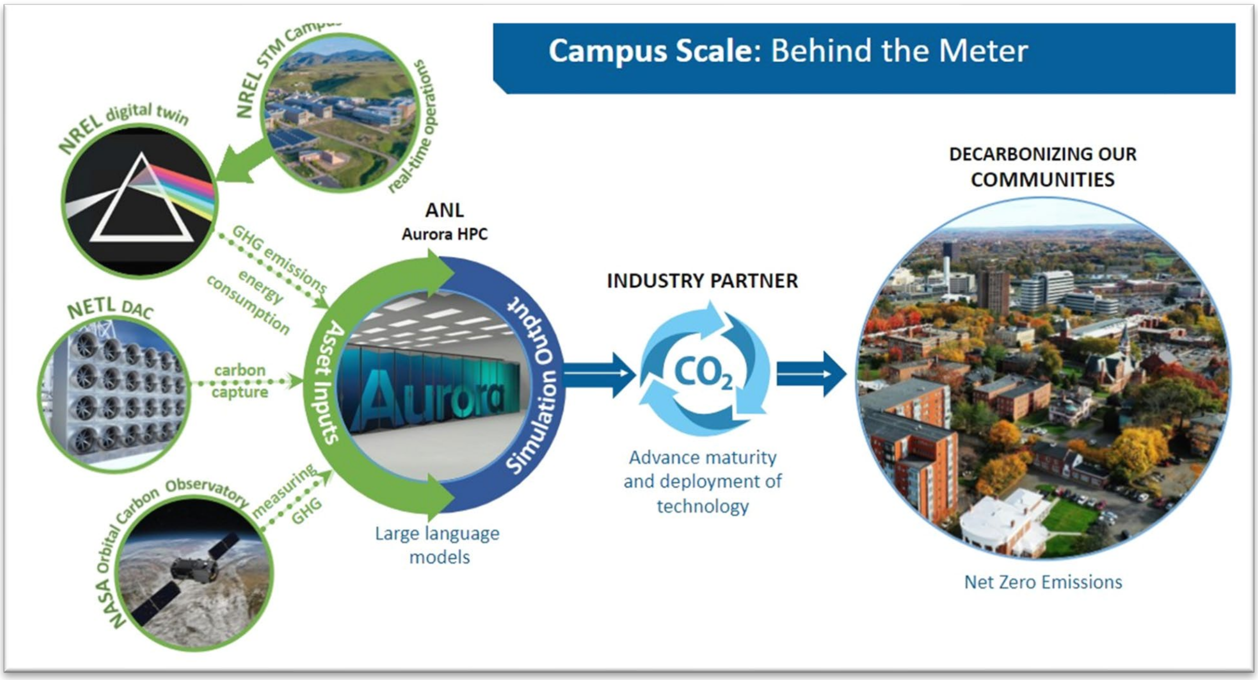



Fig 4: DOE Direct Air Capture Grand Challenge can benefit from a diverse array of inputs to shape solutions

Below we illustrate a scenario question for the development of a DAC technology that will reduce Greenhouse Gas (GHG) emissions. It can not only perform that role but be synergistic with HVAC units to reduce energy at a building level scale. When coupled with the addition of digital twin data that measures building's real-time performance/GHG and the measured levels of atmospheric GHG data (obtained through satellite feeds from NASA's Orbital Carbon Observatory) in that specific location (utilizing NREL's STM campus) we can understand how effective the DAC is in removing $CO_2$ levels and how efficient the HVAC technologies are reducing $CO_2$ consumption. Having more intelligence into the operations and impacts of real-world settings the data collected is increasing richer understanding for the technology to be responsive.

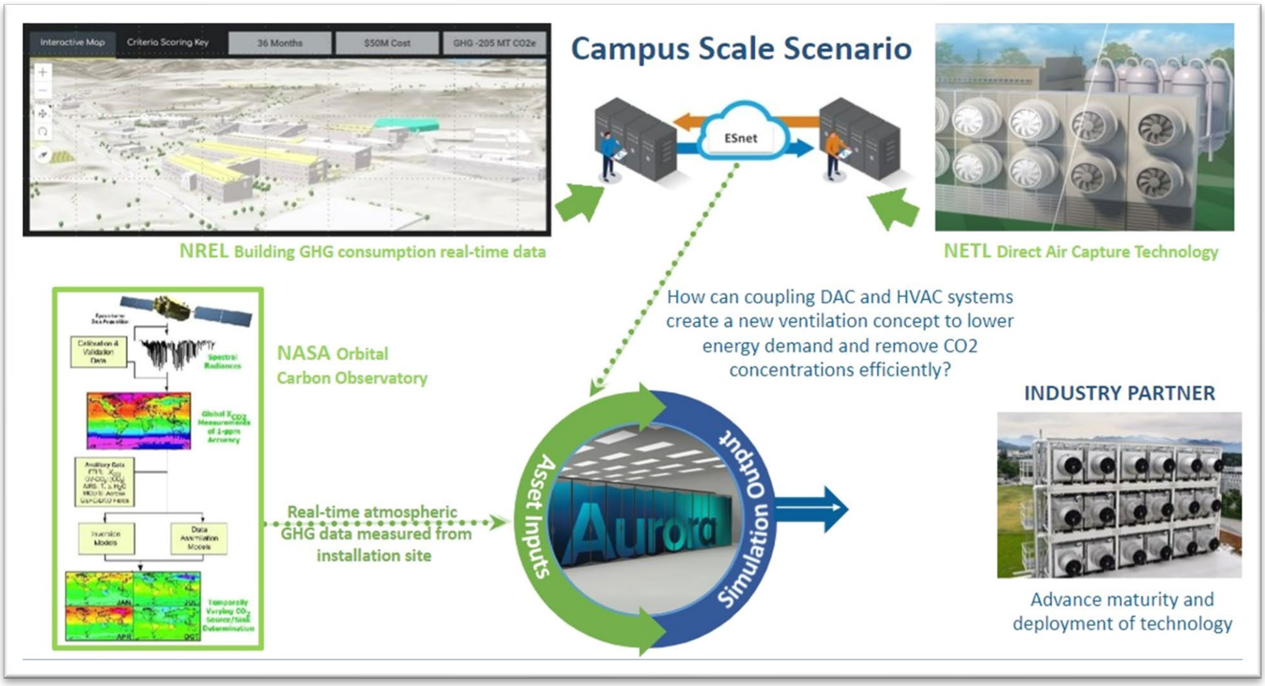



Fig 5: Ideation through production can be investigated in this virtual environment

**APPENDIX C**

National Laboratory Models

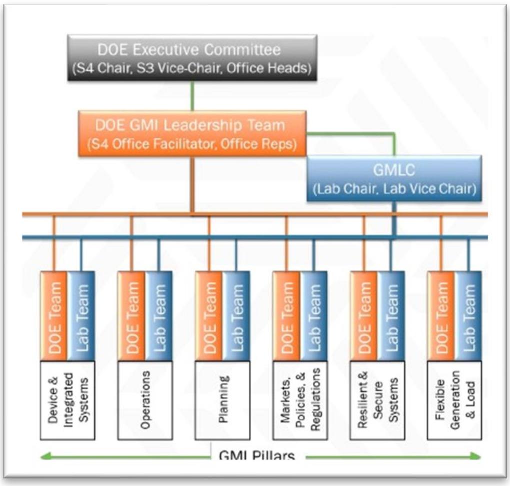

***DOE Super Lab 2.0*** was deployed at NREL in 2023 combining Advanced Research on Integrated Energy Systems (ARIES) capabilities with a controllable grid interface, digital real-time simulator, and renewables and ESnet's OSCAR service that provides secure and synchronous data exchange. It targets the demonstration of 10,000 interconnected devices between DOE National Labs, which serves as a precedent to a fully interconnected lab complex. This venue investigates energy system research that leverages unique assets and expertise at multiple labs to evaluate scenarios that reflect the complexity of the modern and evolving energy grid to address challenges at utility scale applications. The operational tectonics of this installation approach serves as a replicable model where in the virtual demonstration complex other sector challenges can be explored such as carbon capture management, sustainable aviation fuels, and distributed energy districts to produce technology solutions that become components in these system topic ecosystems.

***From Theory to Practice***

In January 2023, NREL and INL demonstrated a unique hybrid power plant connected by high-speed network bring renewables and nuclear together. This unique installation virtually linked a solar array, lithium-ion battery, hydrogen electrolyzers, and a nuclear reactor in real time.

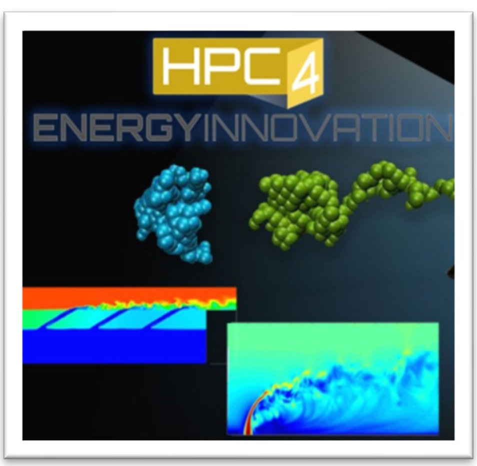
"*Innovation without implementation is merely an idea, but at-scale validation is the bridge that makes ideas a reality*", stated ARIES team lead Rob Hovsapian,"*the engine that powers this evolution, connecting multiple assets and de-risking complex energy systems for faster adoption of novel clean energy technologies."* This installation allowed our two National Laboratories to study energy systems that are currently not in existence. This model is extendable to establishing the virtual demonstration complex to investigate other clean energy pursuits that are significant challenges.

***DOE Grid Modernization Laboratory Consortium*** was established in 2014 and convened 13 labs to collaborate in the efficient use of resources, shared networks, knowledge transfer, enhanced lab coordination, and regional perspective and relationships with local stakeholders and industry. The focus

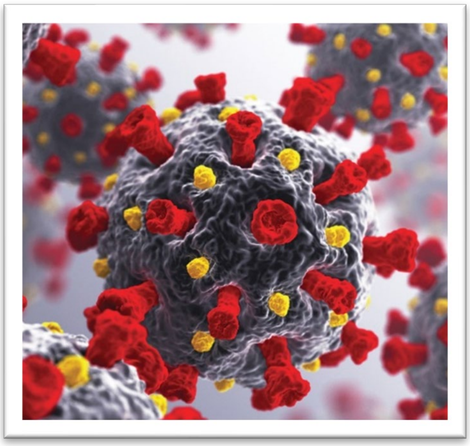



was on modernizing the nation's grid through eighty-eight projects managed by the National Laboratories. Funding was released through DOE's Grid Modernization Initiative. This model represents proven collective results and an effective venue for multiple labs contributing their significant capabilities to a larger research effort to result in a more holistic approach to modern grid development. Through our interviews it was conveyed that there was a rocky beginning due to territorial behavior. This is not a surprise but that reinforces the need for the executive director to be agnostic and apply a change management approach from the beginning to set expectations.


***DOE Net Zero World Initiative*** was formed and announced at COP26 in 2021. Its directive is to partner with global countries to harness the power and expertise of the DOE complex, state department, philanthropic groups, and academia to scale up clean energy deployment and investment. This focuses specifically on the countries looking to implement their climate ambition pledges and translate those goals into technology road maps and investment strategies. This venue is more for climate diplomacy, analytic assessment, and financing for deployment of existing technologies versus the discovery and advancement of new technology solutions. This example offers how the National Laboratories were aggregated together contributing signature or core capabilities to apply to clean energy use in buildings, industry, electric power, transportation and agricultural sectors. The governance structure produced teams at each laboratory and activated depending on use cases needed with each individual country.




***DOE HPC4 Energy Innovation*** was established in 2015 to partner with industry by leveraging world-class computational resources at the National Labs for materials and manufacturing development. Many successes were achieved in addressing manufacturing challenges in steel and aluminum, jet turbine design, advanced materials for light weight and high temperature, high corrosion applications and chemical processing. This linked mission science capabilities from eleven National Laboratories and utilizes 22 computational resource systems from nine National Laboratories. Key to evolving the technical solutions needed in the virtual demonstration complex is how simulation and emulation platforms and data processing can occur to answer key research questions. This venue also exemplified how early research applications were evolved for commercial partnership technology maturity.



***DOE National Virtual Biotechnology Laboratory (NVBL)*** was established in 2020 through funding obtained by the CARES Act. NVBL is a consortium of DOE National Laboratories each contributing a core capability relevant to the threats posed by COVID-19. It virtually links other DOE user facilities, including light and neutron sources, nanoscale science centers, sequencing and bio-characterization facilities, and high-performance computer facilities, to address the key challenges in responding the COVID-19 threat. This model represents the DOE's ability to fabricate a venue in crisis to an existential threat by linking the labs signature capabilities in a virtual venue. Relevant to this application was the production innovation in materials and advanced manufacturing that mitigated shortages in test kits and personal protective equipment. It is also a successful example in creating partnerships with other federal agencies such as the department of health and human services, Department of Defense, and Federal Drug Administration and external partnerships such as Coca-Cola, Thermo Fisher Scientific, BioMedInnovations, and municipalities. The proposed virtual demonstration complex needs to investigate scaling challenges to deliver clean energy technologies to market working with industry and other federal agencies contributing subject matter expertise.

# Becoming Better Together: Advancing a Sense of Belonging in the National Laboratories

Mark Barnes (SRNL), Lorena Basilio (SNLs), Elizabeth Hong-Geller (LANL), Wibe Albert de Jong (LBL), Alistair Rogers (BNL), Josh Schaidle (NREL), Elizabeth Wheeler

With input from: National Laboratory Chief Diversity Officers, National Laboratory Ombuds, The Director of the DOE Office of Scientific Workforce Diversity, Equity, and Inclusion, The Deputy Director of the DOE Office of Diversity, Equity, Inclusion and Accessibility, Representatives from the Cohort 5 DEI think piece.

Each National Laboratory has core values that guide the execution of its respective mission and that seek to create a sense of belonging for its employees. However, to move from core values to a culture with a resilient and sustainable focus on Diversity (D), Equity (E), and Inclusion (I) we need to provide our employees with the necessary tools and training. We identified some best practices, and recommend that individual Laboratories consider adopting these DEI best practices to equip our workforce with the tools they need to translate their Lab's core values into an embedded and sustainable culture that supports a sense of belonging across our National Lab complex (Figure 1)[1].


**Fig 1** Piecing together National Laboratory best practices will transform values into an embedded resilient DEI culture

Increasing the sense of belonging within the National Labs is not just important from the standpoint of equity but is key to unlocking the full potential of the National Lab system—a lack of diversity stifles innovation[2]. Diverse, equitable, and inclusive workplaces are important considerations for recruiting[3] and retaining the next generation of National Lab employees, a challenge that will be exacerbated by demographic change that will increase competition for graduating students[4,5,6]. If National Labs fail to create respectful workplaces, they risk losing a generation of talent. The incivility that flourishes in poor workplace cultures also decreases work effort, work quality, focus, performance, and commitment[7]. While National Labs cannot always compete with the private sector on salary and benefits, they can compete on mission and culture. If we don't create respectful, civil, inclusive workplaces where people can be successful whilst being their authentic self, the National Labs risk losing their relevance and the mission will suffer.

### Our DEI Journey across all 17 DOE National Laboratories

The DOE has a DEI strategic plan for the complex[8], and the National Labs have their own strategies in alignment with this plan. Similar to our collective, and individual safety cultures—as highlighted by the previous OSELP cohort's discussion on this topic[9]—DEI can be, and is being, embedded at all levels in some of the National Laboratories. Currently, ten Office of Science Labs include DEI accountability on their performance appraisals. One recurring theme we saw that helps spread this cultural change was the value and impact of employee resource groups (ERGs). Whether they were providing a voice to employees to discuss critical matters, developing documents to help guide and educate the workforce[10], creating DEI case studies, assisting leadership with communication, or just providing psychologically safe places of belonging, these groups should be supported and leveraged to ensure the National Labs are listening to their employees, and developing cultures of inclusivity and belonging. Continuing to learn from each other and sharing best practices, as exemplified by the first DOE ERG Summit,[11] is a critical step in building sustainable DEI efforts. The resources available to ERGs varied widely among the Labs. **We recommend greater funding to support ERGs, including resources to support employees' time**. Further expanding access to funding beyond ERGs could enable employees to increase their engagement in DEI activities and reduce barriers to making meaningful contributions.

## Key Challenges

### Resilience

The visible and centralized structure that supports DEI initiatives at most National Laboratories can easily be taken for granted but could be quickly dismantled following change in organizational or political leadership. This vulnerability threatens current progress, and ultimately jeopardizes the mission of our National Labs. We believe there is a need to decentralize DEI efforts within the National Labs and to develop an undisputable framing for DEI that enables people across the political spectrum to recognize and support the value of a workplace that is respectful for all employees.

### Promotion

Although current efforts underway at the National Laboratories move beyond compliance and towards a focus on improving culture[12,13,14], individual and institutional biases still exist in our workplaces[15]. These biases favor the retention and promotion of privileged groups and disadvantage underrepresented groups—the cultural and structural barriers to participation are not experienced equally (Figure 2). It is critical to identify the gaps and barriers in our processes and to integrate policies and procedures that promote DEI in our workplace. In fact, DEI efforts are actually at odds with many existing institutional structures as these efforts compel us to challenge existing policies and procedures. Promoting and embedding DEI throughout our Laboratories will be critical as we strive to build a culture of belonging. Studies have shown that a sense of belonging is a key indicator of a successful DEI program, and that organizations with a high sense of belonging have more engaged employees and have higher retention rates[7,16]. **We recommend an examination of systems, policies and processes, and the integration of DEI throughout Laboratory operations.**


**Fig 2** The hostile obstacle course that women and underrepresented minorities have to endure in Science (Berhe et al., 2020)

### Culture

***Code of Conduct***

There is a grey space between acceptable behavior, and actions that are illegal or that would typically result in disciplinary action. Behavior in this grey space has an outsized influence on culture, and can set the tone for an organization if left unchecked. We believe the use of Codes of Conduct, also called Workplace Expectations or Norms for Respectful Behavior, can improve discretionary behavior in this grey space and help advance DEI within the National Labs. Currently, procedures for addressing inappropriate behavior are often focused on a legalistic complaint apparatus that addresses issues of compliance and typically those behaviors that rise to the level of public consciousness[17]. For example, gender harassment—the put downs, not the come ons—associated with sexual harassment are much more common and largely ignored by institions[18]. As institutions seek to change their culture, leaders need to confront negative behavior directly and decisively without waiting for formal complaints[18]. Good Codes of Conduct can be impactful in helping to promote safe and inclusive workspaces[19]. We reviewed Codes of Conduct from the National Laboratories that had them and found them to be focused on compliance and policy. In several cases they did not address bullying, harassment, microaggressions or other exclusionary behavior. **We recommend that National Laboratories write, or revise, their Codes of Conduct to reflect their aspirational values, call out desired behavior, describe inappropriate behavior, include clear reporting structures, and clear consequences for violations[20]**. Codes of Conduct could be linked on homepages both demonstrating and advertising commitment to DEI that can help with recruitment. Giving Codes of Conduct teeth and following through will set expectations and give leadership a foundation for action to help cultivate a safe, respectful and professional workplace. An effective Code of Conduct can be a springboard for cultural change, but leadership and employees need tools to uphold that Code of Conduct, in real time, during the moments that matter. Currently, not all people are not equipped to handle these moments.

***Training for Enhanced Situational Awareness***

Changing culture requires behavioral change. A code of conduct can set expectations for desired behavior, but employees need tools to help them advance and defend a culture of belonging. They need help recognizing harmful behavior, and help acting in the moment to neutralize it. We see an opportunity to offer staff the tools and dedicated time to practice recognizing and responding to inappropriate behavior such that their ability to recognize and respond becomes second nature. In the prior Cohort's DEI Think Piece[9], they proposed DEI principles that mirror the Safe Conduct of Research principles developed jointly by the Battelle-affiliated laboratories. To support the translation of these principles into behaviors, we propose a simulation-intensive training framework that, in conjunction with Codes of Conduct, can enhance situational awareness for fostering belonging, inclusivity, and equity within the National Labs. There are many examples of this type of training that have been shown to be particularly effective in combatting harassment, bullying and other exclusionary behavior[e.g. 21]. In addition, this training framework builds on the recognition that if we can change someone's behavior, we can often change how they think.

Situational awareness is the ability to perceive, understand, and effectively respond to one's situation, especially for enabling quick and safe responses to hazards. Intensive, in-person simulations to practice reactive and proactive responses for improving DEI in real scenarios taken from lived experiences at National Labs would address the key elements of situational awareness. Such training would build muscle memory (it takes an average of 66 days for a new behavior to become automatic), provide employees with the tools they need to act, and the confidence to do so. This practice, facilitated under pressure, is a critical springboard in changing behaviors. Fortunately, the National Labs have embraced this type of training, e.g. Battelle's Laboratory Operations Leadership Academy (LOLA) and Laboratory Operations Supervisor Academy (LOLA) program, LLNL's Managing the Moments that Matter training, or LANL's interactive bystander training. A key challenge with this type of training is its scalability. **We recommend**

**National Labs evaluate options to lower the barrier for access to situational based training focused on defending DEI and increasing a sense of belonging**. A few potential options include augmentation of existing programs like LOLA/LOSA (as highlighted by Cohort 5[9]), multi-lab joint procurement of content from external DEI experts and training organizations, creation of training modules that can be modified to fit each Lab's specific needs, and the development of virtual reality programs. Importantly, this training should be supported by educational content targeted at building a shared understanding of the meaning and value of belonging. By having a shared understanding, the tools, the practice, and the courage to take action, we can advance the culture of belonging from the top down and the ground up.

### Accountability

Culture change requires accountability and DEI initiatives are futile without accountability because it is not just the organization or the policies that must change but the behavior of its employees[22,23]. Following the example, and success, of changing the safety culture at National Labs, all employees should be personally responsible for ensuring DEI in research and operations[9], but leadership must value, model, support, and fund desired change. To have a resilient DEI culture, accountability should be clearly articulated for all levels of the organization. For example, members of a Laboratory's leadership team should establish who is accountable for delivering various DEI efforts but also provide time and resources to help them be successful. Another powerful step is to consider external assessment. For example, from the American Physical Society Committee on the Status of Women in Physics[24].

We believe that a key step to enabling accountability is collecting data. **We recommend that the Labs consider what data they need, and establish metrics, measurement protocols, and tracking procedures**. Data is a mirror of our biases and our realities, and that DEI is a never-ending journey[25] Without data it is hard to see those biases and impossible to measure progress. In many cases key data are not currently collated preventing a full understanding. For example, while hiring demographics are routinely reported, attrition and career advancement also need to be tracked and analyzed. While developing leading indicators of inclusion and belonging is undeniably difficult, it is imperative that we continue to challenge ourselves to develop these metrics for the health of our organizations.

In closing, fostering a sense of belonging will serve as a competitive advantage for the National Laboratories, now and into the future, and show our leadership and commitment to DEI in the broader scientific and research community. To that end, a powerful coordinated action could be a public statement by the National Laboratories outlining their commitment to a future culture where diversity, equity, and inclusion are core values.

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# Future of Work Reinvented

Allison Bennett Irion (ANL), Elizabeth Hong-Geller (LANL), Mark Jeffers (FNAL), Lijuan Ruan (BNL), Stefan Vogt (ANL), Elizabeth Wheeler (LLNL)

- *What: Attract and retain world-class talent to work at the National Labs*
- *Why: Post COVID, the nature of how we work has fundamentally changed*
- *How: Develop metrics to assess the reinvention of Critical Workspaces and Workforce Development at the National Labs*

### Overview

Following the COVID pandemic, we are living through a fundamental transformation in the way we work. For the DOE complex to continue to deliver on its mission and to attract world-class talent, innovative strategies that incorporate hybrid and remote work, enhanced collaboration, and more effective, creative, and diverse communications will be crucial. As this great experiment unfolds, the ability to develop, capture, and assess consistent metrics will enable us to evaluate our strategies to reinvent the future of work.

The future success of the National Laboratories (NLs) will rely on a healthy workforce and collaborative workplace to ensure that NLs can continue to execute on our mission, both in security applications as well as open science. However, the shifting dynamics of the workplace necessitates re-evaluation of the parameters of the workforce experience. We need to better define the benefits or incentives that combine to form a unique value proposition for the workforce that will entice them to stay and forge a long term career at the NLs. From industry and the business sectors, we know that there needs to be a balance between the workforce's desire for increased flexibility and company profits. For the NL system, workforce flexibility is countered by the unique requirements at the NLs to execute on our national security mission. Nevertheless, the NLs' capacity to offer flexibility, effective mentoring and training, and a collaborative environment with reduced bureaucracy will ultimately lead to a more diverse, qualified workforce and greater satisfaction at the NLs. We need to be able to determine what workforce strategies are working and what needs to be improved.

Our thinkpiece assessed two critical requirements for a thriving workforce of the future: (1) Critical Workspaces to accommodate national security mission, and (2) Workforce Development, including a focus on early career staff and mentoring. The workspace and workforce components are inextricably linked, and this interplay affects everything from DOE NL culture to recruitment and retention to job satisfaction.

### Process

We have engaged with senior leadership at multiple NLs with oversight over Infrastructure, Capital Projects, and Science & Technology. These discussions provided valuable insights into both the Critical Workspaces and Workforce Development components of the thinkpiece.

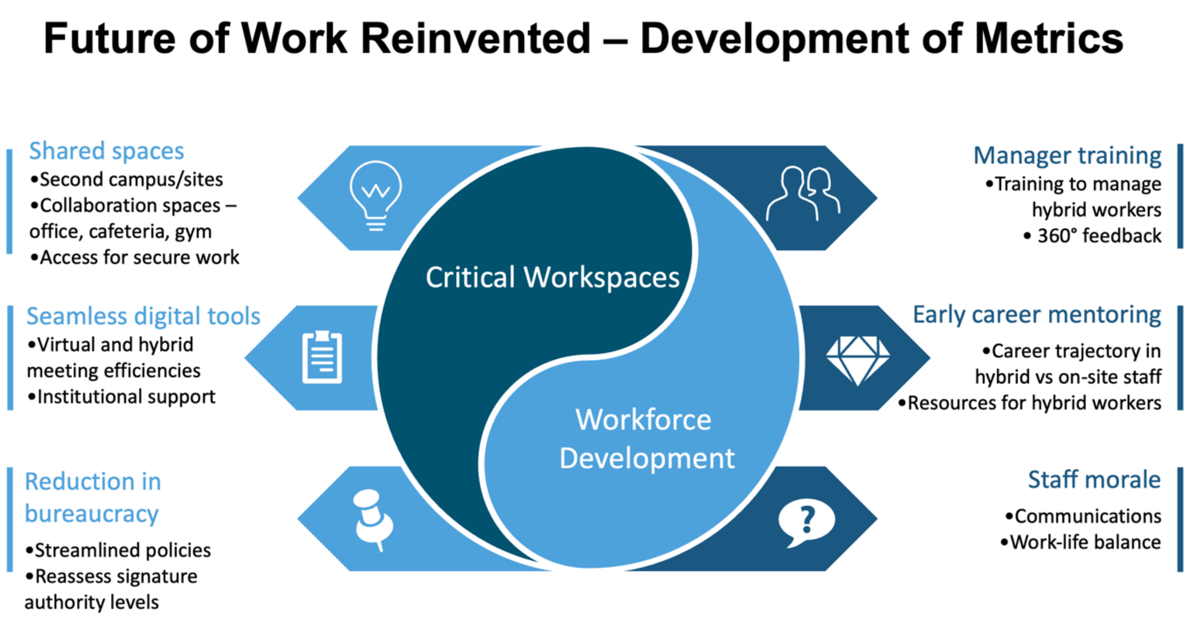
### Challenge

A comprehensive solution space to the Future of Work is complex, vast, and beyond the scope of this thinkpiece. There is a lot of deliberate thinking around strategies to recruit, develop and retain the workforce in business and industry that run the gamut from completely remote to 5 days a week on-site. We are focused on the specific needs and challenges of the NL system, taking into account the unique security envelope and the collaborative environment of open science at the NLs. By interlinking both the critical workspace and workforce development, we propose to define the unique value proposition to recruit and retain staff in the NL system.

As part of this thinkpiece, we have also discussed the art of the possible. Prior to the pandemic, hybrid work was not considered a viable option if workers wanted to have a successful career trajectory. We have considered questions such as whether a line manager can do their job virtually and whether tasks normally done in classified space can be downscoped and performed in the open with proper guardrails. Another important discussion is the cost to the NL system if a new workforce strategy is not implemented. The workspaces that inspire innovation and productivity while prioritizing employee work-life balance will lead to a healthy workforce that is committed to the NL mission.

**Recommendations**

We have proposed an implementation plan that describes targeted incentives and associated metrics in primarily the short-term (1-3 yr) timeframe to track progress in strategies towards workspace and workforce goals. We have downselected two interlinked requirements that are essential for the NLs to develop implementation plans: (1) Critical Workspaces to enable successful teamwork and enhanced work efficiency, and (2) Workforce Development to attract world-class talent that is dynamic and adaptable. For each of these two requirements, we have identified three incentives that we posit will greatly impact a worker's decision to build a career in the NL system. (See Figure below) For each of the incentives, we developed metrics that can be gathered through surveys, management and staff interviews, and other data structures to assess trajectories of both successes and failures over time. The goal is for all NLs to participate in the implementation plan so that there is a concerted strategy for metrics building and shared outcomes between the NLs.



## (1) Critical Workspaces

### A) Shared spaces

Even prior to the pandemic, NLs were looking for innovative infrastructure solutions to modernize workspaces for enhanced collaboration, increase footprint for expanding mission scope, and offer more flexible drop-in and office solutions. Many of the NLs already have second campuses, satellite sites, or workspaces focused on collaboration with academia or industry, while others are exploring the best solution for their specific regional and mission needs. In fact, the Future of Work may include new remote work hubs (both digital and physical) to allow geographically distributed employees to interact more efficiently. On a smaller scale, there is a great need to find the right balance between traditional private offices/cubicles and collaboration or shared spaces. These shared spaces also include common areas open to all staff, such as a cafeteria or gym, where availability of these resources greatly add to staff morale and provide opportunities for impromptu conversations and idea generation. A common thread running through all our Workspaces is the execution of classified work that is unique to the NL system and the importance of capturing those requirements for any workspace solutions.

| | Short term (1-3 years) |
|---|---|
| Second campus/satellite sites | Year 1: Catalog the different strategies by all the NLs to create satellite sites/second campuses and capture the pros/cons<br>Year 2: Examine co-location and facility requirements for classified work at new sites, including re-assessment of classification levels if possible<br>Year 3: Share findings with the NL complex and hold follow-on discussions of lessons learned or new ideas |
| Collaboration spaces | Year 1: Collect data on usage of existing collaboration and shared spaces (drop-in offices and desks/gym/cafeteria);<br>Year 2: Assess classified mission needs and reassessment of some tasks with proper guardrails<br>Year 3: Surveys of NL staff to determine most useful spaces and any barriers to their use |

### B) Seamless digital tools

The pandemic brought rapid and dramatic changes to aspects of work for many people, in particular the need to collaborate virtually. Tools have quickly evolved to improve the quality of such virtual collaborations, and are expected to continue to evolve in response to customer needs. Sometimes rapid adoption of these tools are hampered by institutional delays, and different institutions are using different tools which are not inter-operable, or with restrictions that make it difficult to work across labs. Another challenge is team meetings that require significant interactivity (for example to design new instrumentation, or overcome a problem in a new way, etc.), where some of the participants are in-person and others are virtual. While interactions in person are typically best, realistically virtual interactions are here to stay, and can actually make it easier to collaborate across distances and labs. We recommend investing in tools to make virtual interactions more effective to improve on overall mission delivery.

| | Short term (1-3 years) |
|---|---|
| Virtual and hybrid meeting efficiencies | Year 1: Identify, develop and disseminate best practices for different scenarios. Develop prioritized list of conference rooms to upgrade for effective hybrid meetings.<br>Year 2+: Upgrade facilities as budget permit |
| Institutional support | Year 1: Assemble focus groups to identify prioritized areas of largest potential benefit for common tools and access, start implementation where possible.<br>Year 2: Develop structured process with site offices that make it easy to pilot new tools in one of the labs, and then streamline roll-out to other labs. |

### C) Reduction in bureaucracy

According to the Harvard Business Review, it is estimated that excess bureaucracy costs the U.S. economy more than $3 trillion in lost economic output per year[1]. In addition to the financial cost, internal bureaucracy causes employee frustration and impacts morale and productivity. As an example, the future of work task force at LLNL reviewed comments on glassdoor and found that 25% of all negative comments focused on bureaucracy.[2] With the DOE issuing the report on the enhanced mission delivery initiative (EMDI), now is the opportune time for National Labs to also review their levels of bureaucracy.[3] We recommend focusing efforts on streamlining policies and reassessing signature authority levels.

| | Short term (1-3 years) |
|---|---|
| Streamlining policies | Year 1: Assemble focus groups from across Lab to identify practices, processes and procedures that staff feel are hindering them<br>Year 2: Prioritize list & evaluate possibility to streamline (recognizing that some processes i.e. clearances cannot be streamlined at NL level)<br>Year 3: Revise processes for top 20% |
| Signature authority levels | Year 1: Assemble focus groups from across Lab to identify practices, processes and procedures that staff feel are overly burdened by signatures<br>Year 2: Assemble team to assess which signature processes can be adjusted based on contract etc<br>Year 3: Revise processes and report out to staff |

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## (2) Workforce Development

### A) Manager training

In this post-Covid era of the workplace, there is a shifting dynamic that will require managers to adjust the leadership skills they have previously implemented in the in-person environment to hybrid and virtual teams, to ensure that these new categories of workers remain effective and engaged. Leaders must especially pay attention to creating a healthy culture, building trust, motivating staff, and encouraging interpersonal connections within this new environment. A recent survey found that the leadership skills most needed in 2023 are engaging and developing talent, leading and supporting change initiatives, establishing goals and priorities, and creating a sense of inclusion and belonging. [1] For managers of hybrid workers, it will be especially important to equip them with the tools to be effective communicators, to resist proximity bias or preferential treatment for on-site workers, and to measure success amongst all their employees. Given that managing hybrid workers is a relatively recent construct, 360° feedback for the managers will provide an assessment of the hybrid system and the effectiveness of manager training.

| | Short term (1-3 years) |
|---|---|
| Manager training for flexible workforce | Year 1: Develop curriculum for 'Leading Hybrid Work for Managers'. Areas of focus could include Maximizing Collaboration, Building Trust, Effective Communication, etc for On-Site/Hybrid Teams<br>Year 2: Require all managers to take training and ask for feedback on the content and usefulness in real world leadership, such as classified work<br>Year 3: Continue to modify curriculum based on feedback |
| 360° Feedback | Year 1: Develop 360°questionnaire for staff who are hybrid to provide feedback on their managers and group dynamics and efficiency<br>Year 2: Roll-out 360° questionnaire to hybrid staff; Collect and tabulate feedback for managers; Incorporate into existing performance plans<br>Year 3: Revise and adjust manager curriculum to address any gaps in managing hybrid workers revealed by the 360°feedback |

[1]How to Approach Leadership in a Hybrid Work Environment, Center for Creative Leadership, Jan 2023.

### B) Early career mentoring

Effective early career mentoring includes both formal and informal channels that now need to address hybrid and remote workers. It is vital to enable early-career employees to build relationships, activate their capabilities and actualize their potential. Concerted efforts are needed for hybrid early career staff to build rapport with teams and mentors, which are both hallmarks of success.

Implementation of multiple strategies is needed to provide training opportunities to cultivate collaborations. To determine the effectiveness of these strategies, we propose to assess the career trajectories of remote and hybrid staff compared to on-site, using metrics such as time to promotion, salaries, publications, awards, fellowships, assignments and invitations for speaking engagements. We also suggest formalizing stay interviews to understand current job satisfaction, perceived access to career development opportunities and to learn what incentives are important for growth and impact of their career at the NLs. These interviews can also provide feedback on what resources remote and hybrid workers need to be successful and happy employees.

| | Short term (1-3 years) and Long term (5-7 yrs) |
|---|---|
| Career trajectory in remote/hybrid vs on-site staff | Year 1: Develop and implement metrics for early career remote, hybrid vs on-site staff (I.e. promotions, publications, mentoring, developmental opportunities) over multiple years<br>Year 2: Perform stay interviews for early career staff to determine job satisfaction incentives that entice them to stay |

| | |
|---|---|
| | Year 3: Incorporate feedback and assessments into improving the early career experience |
| Resources for remote and hybrid workers | Year 1: Assemble a team to examine resources for hybrid workers (I.e. mental health, psychological safety, and wellness, remote office set-up)<br>Year 2: Develop and implement culture survey and/or interviews directed at the remote and hybrid workers to determine their needs<br>Year 3: Incorporate survey and interview feedback into resources for remote and hybrid workers |

## C) Staff morale

Staff morale is one of the topmost deciding factors that determine an organization's ability to hire and retain staff and ensure a consistently high level of productivity. Effective communication of NL mission and culture of positivity, as well as honest discussion of the challenges that NLs face, will lead to trust in leadership. When an institution uses poor communication, such as staff being informed of various policy changes that negatively affect their work or life with little warning, there will certainly be a decrease in staff morale, reduction of productivity and creativity, and eventually talent loss. Post-pandemic, remote and hybrid work have become the new norm, and many employees appreciate the better work-life balance with flexible work schedules and a reduced commute time. Managers will need to adopt flexible problem solving for coordination of staff in multiple work arrangements and intentional engagement with staff. A better work-life balance should be encouraged equally for everyone. It is imperative to create an inclusive workplace that engenders a sense of belonging through shared culture and fate to attract and retain diverse talent. To accurately gauge the health of the organization, culture surveys should be taken every 1-2 years to assess staff morale, especially in such a dynamic post-pandemic environment.

| | Short term (1-3 years) |
|---|---|
| Communications | Year 1: Assess effectiveness of different methods for internal and external communications (e-mail, internal webpage, social media); Sharpen Lab communications if needed<br>Year 2: Develop and implement survey on Lab communications, paying attention to how on-site and hybrid workers access news and information<br>Year 3: Fine tune communications plan based on feedback |
| Work-life balance | Year 1: Develop and implement survey on Work-Life balance, paying attention to differential responses between on-site and remote/hybrid workers<br>Year 2: Look for opportunities to enhance work-life balance for all staff (e.g. support systems, flexible schedule, self-care)<br>Year 3: Fine tune organizational culture based on feedback |

# Discovering the National Laboratory Ecosystem (where you fit in the complex)

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- *What: OSELP Fellows are amazed at the breadth of the complex and its missions when exposed to the many labs during the multiple site visits and recognize the value of sharing this essence of the experience with a broader lab staff audience.*
- *Why: National Laboratory Staff would garner a better understanding of an integrated ecosystem that collectively works to advance the varied missions of DOE.*
- *How: A pilot program to offer staff across the Complex a view of the labs, missions, programs, and capabilities through site seminars, periodic complex-wide webinars, and an assembly of on-line resources.*

### Overview

The Oppenheimer Science and Energy Leadership Program (OSELP) has provided six cohorts, more than 100 professional staff, with unique exposure to the widely varied DOE National Laboratory (NL) Complex. Even as experienced professionals with many years of service, OSELP alumni are amazed at the breadth of the complex and its missions during the multiple site visits. Thanks to the investment by lab directors in OSELP, such exposure is creating strong, connected laboratory leadership that benefits DOE by building Complex-wide trust and understanding. We, as soon-to-be OSELP alumni, want to pay it forward by further sharing these benefits with more DOE laboratory staff, ultimately instilling a greater sense of pride and dedication to working within the National Lab system.

This Think Piece proposes a program to offer employees across the NL Complex windows to learn more about the labs, missions, programs, people and capabilities through onsite seminars, periodic complex-wide webinars, and an assembly of on-line resources. Initially, we propose to pilot the program at a subset of labs with two or three rounds of targeted presentations and webinars to assess feasibility and successes. This would then be expanded to additional laboratories and the entire complex based upon feedback from the pilot. Employees will garner a strong sense of belonging and a complete understanding of an integrated ecosystem that collectively works to advance the varied missions of DOE. This would not replace the current laboratory-specific training and orientation that employees already receive, but rather would be complementary. A stronger sense of belonging and increased awareness of the broad mission impact could potentially help with retaining staff and sustaining the strong history of drawing only the best and the brightest to the complex. Additionally, this program may also have the benefit of inspiring and building the next generation of leaders for the DOE labs of the future.

Why would the NL complex benefit from this activity? Currently, each laboratory and facility provide orientation to new employees that predominantly focuses on their specific facility. Such orientation is understandable and necessary but often misses, or only briefly touches, on a more complex-wide perspective. Employees may develop a sense of mission for their laboratory, and projects, but may fail to establish that same relationship at a higher level. Many on-line resources are already available at many locations, with various levels of organization. Viewing these resources is like opening a box of old family photographs without information on who is in the pictures or when they were taken and how they relate.

Our proposal seeks to build on these resources by cataloguing them in a way that benefits everyone, including our hardworking Human Resources and Communications colleagues who do so much to share our individual lab stories. We are energized by the idea of creating a cohesive family album that conveys perspective, mission and meaning to all Laboratory employees.

**Process**

This Think Piece team has reached out to the leadership of the NLCCO Council to discuss the concept, issues, ongoing activities, and inquire into future assistance with hosting activities. The team has also held similar discussions with the leadership of the OLN. The team also intends to reach out to the NLCHROs for acceptance and guidance, and the idea was discussed with a limited number of newer laboratory staff to see if there was interest. The idea has been presented to experienced laboratory leaders at a Red Team Review and the status of a brief introductory video currently under development by the NLCCO Council for use at DOE headquarters has been monitored. Members also reviewed numerous online resources, such as the motivational video "Answering the Call" produced by Oak Ridge National Laboratory.

**Recommendations**

- The primary method to share this complex-wide story would involve an introductory presentation at each laboratory by an OLN fellow(s) from that laboratory as well as quarterly complex-wide webinars. Building on the pilot, this Think Piece proposes an OLN sponsored National Laboratory employee toolkit in partnership with the NLCCO Council that could include videos, prepared materials with links to additional media and information, onboarding initiatives, and orientation assets. Combined, these will help employees better understand the DOE-National Lab system, the exceptional impact this system has on national security and science and technology innovation, and the important role both the employee and their organization play within this ecosystem.

- The lead activity proposed by this Think Piece is an introductory presentation at each laboratory given by an OLN fellow from the laboratory. This presentation would be structured to describe the knowledge gained as an OSELP fellow – to briefly describe the NL Complex and the varied missions – introduce the employee toolkit, and finally introduce the upcoming complex-wide webinars. Coordinated use of a brief introductory video could succinctly and compellingly describe DOE, the National Labs, and other key organizational elements such as NNSA's plants and sites, DOE User Facilities, and field and site office elements.

- A second major activity would be complex-wide webinars held quarterly. These would be presented by an OLN alumnus, providing exposure and opportunity to the organization or a complex mission or facility, via a webinar. With the completion of OSELP cohort 6, there will be well over 100 OLN fellows across the DOE NL Complex who could participate without significant burden to any one individual. Additionally, such webinars could be recorded and archived in the proposed toolkit.

- Finally, we propose assembling an on-line tool kit prepared from existing materials and current information and resources, which would be reviewed during assembly for content and appropriateness. It would need to be organized with links to existing resources.

Ultimately, a more extensive video or video series could be orchestrated and would be lengthier, perhaps as much as an hour in length and would have some technical "meat on the bones"—describing the types of work being done across DOE—but also would compellingly and inspiringly frame this work as DOE and the NLs solving “big national and global problems.” Each National Lab and major DOE organizational element would be identified with content covering their key mission domains. An example of such informative, descriptive, or motivational videos that could be assembled would be “Answering the Call” produced by Oak Ridge National Laboratory.

The Think Piece team recommends the next steps in advancing this Think Piece:

- Concurrence from the NLDC to pursue the pilot phase of this Think Piece – establishing site presentations and complex-wide webinars through the OLN and NLCCO Council.
- Working with the OLN leadership to assume management of the presentations, webinars, and organization and maintenance of the toolkit.
- Working with the NLCCO Council to assume sponsorship and management of presentations. The Chair of the Council indicated their current video and exhibit were just the first foray into this type of activity with plans to expand resources for the NL Complex in the coming years.
- Contacting the NL CHROs for awareness, involvement, support, and guidance. Any video and toolkit would need to be adopted for employee use and could potentially be administered through this group.
- With involvement of the NLCCO Council, establish a multi-lab steering committee to define a path forward and address issues of retention, accuracy, and maintenance.
- Identifying Communication Leads (e.g., the NLCCOs or staff) at the NLs to assist or take a lead role in content development.
- Compiling best practices for this kind of project from industries outside of the National Lab Complex.
- Establishing a project timeline/plan.

### Challenges

A national laboratory ecosystem toolkit featuring site presentations, webinars, an introductory video and other media resources is feasible and could be initiated in phases, starting with a pilot at a few interested laboratories. Working in phases, the cost associated with these efforts could be tailored to available resources. Site presentations, webinars, and use of the introductory video being developed by the NLCCO Council would take minimal funding and could be implemented quickly in a pilot at interested laboratories. All webinars could be recorded and archived in the proposed toolkit to expand their impact with minimal additional cost. Production of a lengthier video or video series would take more resources and could be implemented after the program was piloted.

The biggest challenge is establishing ownership and advocacy, whether by the OLN or NLCCO Council. The program and toolkit will require ownership by a central organization to implement and ensure it is kept current and relevant. The Chair of the NLCCO Council described keeping the content current as the biggest challenge to any project such as this one. Components of the toolkit could be assembled from existing and current information and resources, which would need to be reviewed for content and appropriateness. It would need organization with links to existing resources. It is envisioned that the OLN and/or NLCCO Council would partner to assume custodianship and compile, organize, and distribute the tool kit.

All members of the national laboratory complex should be able to use the developed resources. As such, Americans with Disability Act (ADA) compliance will be incorporated. Additionally, participant feedback will be sought for all activities to enable continuous improvement of the presentation and toolkit.

One additional concern is that increased staff awareness of the entire complex and the exciting mission opportunities could result in increased staff movement between laboratories. Laboratories, however, might see an increased potential and view these as benefits to DOE and the NL Complex rather than a loss of resources to the individual labs. More broadly, this effort could assist in retention of staff complex-wide and lower attrition from the lab complex as a whole.

# Leveraging OSELP Alumni: Proposed Use Cases to Support the NLDC in Advancing the DOE-Lab Complex

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- *What: Thanks to the investment of the National Lab Directors, we have over 100 OSELP alumni across the Complex whose diverse expertise, connections, learnings and leadership are ready and energized to serve NLDC and DOE priorities.*
- *Why: OSELP alumni bring a unique combination of broad Complex knowledge, deep expertise in their fields, and a trusted network of colleagues and communication that can be swiftly activated across all functions of the labs.*
- *How: Engage OSELP alumni in key existing lab-wide committees and pilot new ways to leverage the network, including Strategic Peer Reviews and rapid-teaming to address black swan events*

### Overview

The DOE National Labs are considered the "crown jewels" of the nation's research and innovation ecosystem[i] and are often referred to as "hidden gems". The Oppenheimer Science and Energy Leadership Program (OSELP), with its diverse brain trust, is a diamond within that gem collection. Currently in its sixth year, OSELP brings together emerging technical and operations leaders to gain a system-level understanding of the DOE-Lab complex. Fellows are exposed to strategic and operations challenges at each of the individual labs and gain a deeper understanding of the challenges that face the DOE-Lab system in totality. Fellows also benefit from becoming part of a growing alumni network, the Oppenheimer Leadership Network (OLN), committed to advancing the DOE-Lab system. This network has evolved into a distinguished and growing community of over 100 thought leaders from diverse backgrounds with requisite knowledge, skill and broad technical backgrounds and expertise. Consistent with the goals of OSELP and the OLN, this think piece proposes three use cases for leveraging OSELP alumni to continue to support the NLDC and individual committee members on addressing emerging challenges. One use case leverages alumni for focused evaluations in mission-critical areas (Strategic Peer Reviews). A second use case utilizes alumni expertise to respond effectively to disruptive technologies like GenAI and support crisis events such as the Covid pandemic. The last use case aims to foster connections among alumni participating in national lab sponsored or endorsed leadership programs such as PLI and OSELP, with the goal of collectively addressing emerging challenges, sharing best practices, and supporting the priorities of the NLDC and DOE. These use cases provide opportunities to support the National Laboratory directors' priorities, enable OLN members to maintain their connections with fellow alumni, continue to grow in their leadership journey, and remain informed about the latest developments and challenges within the DOE-lab system.

### Process and Acknowledgement

This think piece concept evolved during Cohort 6 team members reviewing prior Cohort think pieces and discussions related to the establishment of a multi-disciplinary team that could be assembled quickly with OSLEP alumni to provide expertise, insight and advice on specific lab challenges. This team recognized the efforts and commitment of the Cohort 3 team's establishment of the OLN and determined that an additional building block should be added to help continue to grow and mature the OSLEP alumni. Team members received feedback and valuable insights from the OLN Chair, broader OLN network, OSELP mentors, and Mark Peters.

**Use Cases: Leveraging OSELP Alumni**

**Use Case 1. Pilot a Strategic Peer Review (SPR) process utilizing OSELP alumni to provide insights to individual NLDC members for topical mission areas of interest. This review is initiated through a request from an NLDC member or delegate.**

**Benefit.** Utilizing OSELP alumni to conduct candid peer reviews of existing or emerging mission areas is an opportunity to leverage the brain trust the NLDC has invested in, provides additional growth opportunities for the individual OSELP alumni, and provides the individual labs with a broad national lab complex perspective and insight into potential blind spots and opportunities. Lab leadership teams are provided with recommendations on blind spots, potential partners, and areas for collaboration on existing and emerging mission areas. An SPR will result in supplementary data that can be used by the requesting leadership team as they make strategic decisions and investments.

**Proposal.** At the request of an individual lab leadership team, a group of OSELP alumni will be assembled to perform an SPR on the specified area of interest. An SPR is a candid "behind the scenes" look at the area of interest to understand potential opportunities and/or blind spots. It complements other assessments, audits or external advisory committees in that the SPR provides a perspective from the broad national labs landscape and missions.

Details on the differences between an SPR, External Advisory Board/Committee, and an assessment/audit are described in Table 1. An SPR takes place over one week, with 1–3 focus areas related to the topic of interest. The team is selected by the requesting lab leadership team in partnership with the OLN POC. This team is led by OSELP alumni and could include other experts as requested. The SPR team collaborates with the requesting lab leadership team on the specific focus areas, approach, and desired outcome. Examples of potential focus areas are found in Figure 1. The SPR review results in a briefing to Lab Leadership that includes observations and recommendations.


**Figure 1.** Example Focus Areas for a Strategic Peer Review (SPR)

**Table 1.** Comparison of Assessments, External Advisory Boards, and SPR

| Assessment/Audit | External Advisory Board/Committee | Strategic Peer Review (SPR) |
|---|---|---|
| • Has a specific structure and can be anywhere from one day to multiple weeks<br>• Team NOT normally identified by host lab<br>• Has a written plan, lines of inquiry and formal report<br>• Tends to be compliance-based<br>• Is designed to identify specific findings, non-compliances, etc. and creates an action list<br>• Focuses on technical details<br>• References requirements (policy, federal drivers, etc.)<br>• Priority is technical SMEs reviewing technical content | • Is an evaluatory committee (strategy, operations, capabilities, protocols, etc)<br>• Typically 1-3 days<br>• Size can range from 5-15 which is defined by the host Lab<br>• Intent can be to advocate (i.e to sponsors or other external entities) and/or to provide expert advice on improvement<br>• In some cases is thumbs up/thumbs down, rather than conversational<br>• Often a fair bit of polish is desired to impress, regardless of intent<br>• Outcome is an assessment of the desired evaluatory elements (strategy, operations, capabilities, protocols, etc) highlighting good points and areas to improve. Initial feedback before the team leads the Lab with a more polished report arriving usually within 1 month | ▪ Focused on mission and emerging mission areas including potential blind spots, areas of potential collaboration, competition, partnerships, programmatic strengths and weaknesses<br>▪ Provides a perspective from the broad DOE National Lab landscape and mission<br>▪ Review is conducted in 2-4 days<br>▪ Team is between 5-10 OSELP alumni and/or experts from across multiple labs<br>▪ Host Lab team and OLN work together to identify desired team<br>▪ Approach is based on conversations with key staff (minimal presentations and not staged or "polished")<br>▪ Outcome is a briefing with observations and recommendations conducted at the end of the review before team leaves the Lab<br>▪ Provides an external perspective for Lab |

| Assessment/Audit | External Advisory Board/Committee | Strategic Peer Review (SPR) |
|---|---|---|
| | • Implications of a "bad" review would have potentially very negative consequences | Leadership on mission and emerging mission areas<br>▪ Is intentionally flexible and not overly prescriptive – majority of time is spent in conversation NOT presentation<br>▪ Is not a technical review<br>▪ Does not identify findings, but makes observations and recommendations<br>▪ Opportunity for OSELP alumni to continue to give back to the Lab Complex<br>▪ No negative implications for recommendations (there is no "bad" review) |

## Specific Operational Process for Strategic Peer Review (SPR)

This section provides an overview of the process for conducting an SPR. It describes the initiation and planning, execution of the review, and success factors.

### Initiation

- Lab Director or member of Lab Leadership team identify targeted mission area for an SPR
- Lab Director or delegate contacts OLN POC to request an SPR team
- OLN POC + Lab POC identify team to supply SPR review
  - Approval of the composition of the SPR team is with the Lab Director
  - Team: Led by OSELP alumni and composed of 5-10 OSELP alumni and/or specific experts requested by lab team
  - Team members are from multiple labs in area of interest – a diverse team – both in expertise and affiliation

### 60-90 Days Before Review

- Team Lead is identified
- Team Lead kickoff w/ Lab POC to understand review request and provide an opportunity for the team to ask questions about needs
  - Discuss scheduling, logistics (hotel, etc)
  - Team should plan to stay at the same hotel if possible, as they will likely need to debrief at night
- Team Lead holds team kickoff to build approach and identify any sub teams

- NOTE: Each SPR sub team should have a corresponding host team liaison that support them during their visit (help with arranging interviews, getting documents, etc). The liaison should have a working understanding of the general area that is being reviewed.

## Review Week

### Day 1

- In brief by the Host Lab leadership on the target area for evaluation
- Overview of focus areas
- Discussion by the SPR Team Lead re: what the evaluation will entail (high level)
- Intro of team and liaisons
- Start conversations w/ key staff (sub teams fan out)
- SPR team debrief every night to identify any threads to pull on day two, additional interviews needed, themes that are emerging, observations

**Interviews/Conversations**

- Interview can include one person/several
- The conversation should be anonymous, unless staff want their names used
- This is meant to be an opportunity to have an honest conversation
- Questions should be open ended (2-4 per/interview) – soliciting information in an open format

**Example Questions**

- What is your experience with…. (insert target area – e.g. use of JAs for mission area X)….
- Are there areas associated with…. (insert target area – e.g. collaborations with industry) that are going well….
- Are there areas that could be improved with…. (insert target area – e.g. having expertise to support capability development)….

### Day 2-3

- Continued discussions w/ staff on key areas with debriefs each night

- Document reviews, as requested (minimize time reading docs versus talking to people)

### Wrap Up

- Provide actionable key themes as a roadmap for the Host Lab to investigate challenges/recommendations
- Occurs at the end of the week BEFORE the team leaves
- Is a simple PowerPoint
- Audience is at the discretion of the Host Lab

### Success Factors

- Team Lead is dynamic leader that can synthesize data and distill themes quickly
- Team motivation and intent is to provide requesting lab with insights into the topic of interest (no hidden agenda)
- Team sensitivity to perception of "stealing ideas"
- Provide a good scrub, but fair
- Embrace organic – find things and pull the thread
- Spend majority of time in the field, not reviewing documents
- Members from multiple labs with unique perspectives
- Members have DOE complex knowledge (landscape understanding)

## Use Case 2. Develop a framework for rapid teaming across the DOE Laboratory complex to enable analysis and response to "black swan" disruptive technologies and events.

### Overview

Black swan events are rare and unpredictable outlier incidents that have an extreme impact, coupled with a tendency for simplistic retrospective explanations for the event.[1] Often, if an impactful event has been considered, swift and coordinated response is likely because of previous investment in preparing for the event. The DOE National Laboratories are prepared for major crises across multiple technology areas (e.g., Nuclear Emergency Search Teams (NEST); Energy Threat Analysis Center). To keep the United States resilient for future areas of vulnerability, the DOE National Laboratory complex needs a framework for rapid development and deployment of special teams to provide efficient and technically comprehensive analyses for disruptive technology and event scenarios. A framework for the DOE National Laboratory Strategic Action Network (DOE SAN), would focus on events that require S&T solutions for complex, unexpected technology disruption (such as how to handle ChatGPT) and crisis events (such as COVID and the Deepwater Horizon well failure). The OLN can serve as an effective team to respond effectively to either a disruptive technology or event at the direction of the NLDC.

The concept for a framework around rare and unpredictable high impact events for the DOE Laboratories is to enable the labs to team quickly with appropriate experts, to enable increasing the efficiency of matching expertise needed and the mechanisms required (contractual, approval, etc.) to pull teams together effectively within short timeframes. This framework would also need to operate within accepted legal and operational requirements. Indemnification issues would be addressed during development of the framework, to limit liability for application of novel technologies towards analysis and recommendations for solutions. The framework also is needed to appropriately engage with other agencies and entities that will be responding to the event (e.g., the Department of Defense). In consideration of disruptive technologies, a similar team may be employed around determining the most effective approach towards enabling positive and beneficial application of the technology within the DOE Laboratory complex. This same team can also provide early technical input to help protect DOE equities and to promote DOE solutions where appropriate.

**The Proposal. Develop a framework before the next "Black Swan" event.**

1. Defining the event: When do we know we have a "black swan?" Who is the ultimate authority and user of the output of the DOE SAN analysis?
2. Identification of the management team
3. Alignment of informal and formal networks
4. Ensuring funding availability and authorization
5. Creating information sharing capability at all levels of control
6. Identifying the Subject Matter Expert team across DOE
7. Collaborating with stakeholders beyond DOE
    a. Other Executive Branch Departments: Justice, Defense, Agriculture, State, Commerce, etc.
        i. NETL can leverage existing relationship with Federal entities
    b. Industry
    c. State/Local Governments
    d. International Governments
8. Utilizing DOE S&T Resources
    a. HPC Computation
    b. Data Analysis
    c. Fielding Experiments

The DOE SAN is expected to provide technical explanations for the disruptive events with responses that are efficient, sophisticated, and agile. The impact of the DOE SAN will result in time relevant solutions, with the goal of minimizing impacts to human life, the environment, the economy, and DOE intellectual property. Additionally, the teams of experts deployed will be able to provide post-event root cause analysis, enabling the United States to prepare for similar events in the future. Ultimately, successful engagement of the DOE SAN will enhance the DOE National Laboratory brand and build morale for DOE staff. In the case of disruptive technological events, the DOE SAN will help the labs naturally share risks and opportunities across the complex to position DOE as the agency of choice to provide substantive advice on how to respond to these disruptions. We note that DOE itself can be the source of technological disruption. Recent advances in ICF Ignition are an example of this disruption.

**Recommendation.** Complete a stocktake of the SAN response framework to determine readiness level of response to future black swan events.

**Challenge.** How do we keep the framework in an at-ready state?

**Proposal.** Develop an assessment of existing infrastructure (communications, compute, data issues and transfer, contracting mechanisms) and people and expertise (map of the solution-driver network – leverage the Oppenheimer Leadership Network). Domain-specific cross-laboratory cells may be a solution to form people-network connections and foster teaming prior to a black swan event. This could also provide a forum to share unique capabilities and expertise, and build an "emergency toolkit." This also could provide a forum for "Strategic Forecasting" to build an agile and responsive framework around "what if" scenarios. DOE SAN is intended to help fill the gaps for situations that are not covered with existing networks and may lead to the development of new formal networks in the future, depending on the nature of the event.

**Recommendation.** Identify small-scale black swan events to test existing SAN team response.

**Challenge.** Identification of these events is challenging. Funding is not guaranteed and may require lab investment.

**Proposal.** Smaller events such as localized industrial accidents may provide a test bed to determine how well DOE labs can coordinate and respond to these unexpected events. This coordination may only require a small subset of the labs, but will help to build understanding of what is required during much larger and more complex black swan events. Additionally, responding to these events has the potential to create new program growth within DOE if response is efficient, resulting in reduced impact from DOE involvement.

### Advisors and Reference Points from Lab Visits

| Individual/Group | Purpose |
|---|---|
| Advisor – George Guthrie, LANL | Experience with Macondo |
| Mike Schlender, PNNL | Operations and interest in framework to enable rapid response |
| Dona Crawford, LLNL | Livermore Foundation |

### Use Case 3. Use the OLN to connect OSELP fellows and alumni to other NLDC-sponsored committees and leadership programs.

**Benefit.** The OLN provides a formal network of OSELP alumni opportunities for networking and continued engagement in future think pieces and other systems-level challenges and opportunities. However, it is often difficult for OSELP think pieces to be successful without broader adoption by laboratory leadership. These ideas need a champion and the people that can affect change are very busy. In addition to OSELP, the NLDC currently supports or sponsors several other disparate leadership programs (e.g. BELT, PLI) and the learnings from the individual leadership programs are limited to the participants in each program. We believe that the OLN could be a vehicle to bring the various leadership programs together under a single umbrella and allow cross- fertilization of ideas. Perhaps more importantly, the OLN could help connect current and former think pieces and other initiatives that are born out of other leadership programs to the NLDC and other national lab leaders (e.g., the Laboratory Operations Board or the NLCxO committees) that have the ability to put these ideas into action.

This proposal would have three primary benefits. First, it would offer enhanced networking opportunities across various leadership programs and national lab leaders. Second, by connecting alumni of OSELP and other leadership programs to NLCxO committees and their priorities, it provides a continuous learning opportunity for the alumni to stay engaged on evolving issues within the national lab system. Finally, the NLCxO committees can receive feedback on their priorities from a group of people that are uniquely educated on the systems-level issues that the labs are facing.

**Proposal.** The OLN is already starting to explore collaborations with the other leadership alumni networks. We propose creating a working group made of alumni from each leadership program to put together a plan for future collaboration. The plan on the steps for collaboration would be developed and shared with the NLDC for awareness.

Connecting the OLN to the Laboratory Operations Board and the NLCxO committees could be done in a phased approach. The simplest implementation would be a request for the NLCxO committees to share their annual priority list with the OLN, which would not require any additional effort or resources. In addition to educating the OLN on the committee priorities, this could help connect current and former think pieces to the NLCxO priorities to improve the chances of think pieces being actionable, and it could solicit feedback from the OLN that the committees might value. Some committees could choose to generate surveys to collect more formal feedback from the OLN on the various items that the committee is considering. Others could choose to present at the OLN quarterly meetings to have more of an open dialogue regarding the priority list. The OLN could choose to structure the quarterly meetings to allow relevant think pieces to be presented in coordination with specific NLCxO committees. All of this could be accomplished without requiring any significant resources other than a willingness of the NLCxO committees to at least share their priorities and entertain the idea of engaging further with the OLN. The committees are under no obligation to take action on any of the think pieces that are presented to them or other feedback that they receive.

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[i] Department of Energy. https://www.energy.gove/articles;impact-does-national-labs-felt-both-locally-and-internationally. Title: "Impact of DOE's National Labs Felt Both Locally and Internationally". December 22, 2016.