Strength Through Science: Optimizing the DOE National Laboratories

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To: Secretary of Energy Brouillette

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Abstract

The DOE National Laboratories constitute a sizeable investment into non-defense research. However, ballooning national R&D budgets have raised concerns into the effectiveness of federally funded research programs like the labs. I analyze the Management and Operating (M&O) contracts that DOE national labs operate by and recommend changes for DOE to increase the effectiveness of the labs.

1 Executive Summary

The National Laboratories are DOE operated FFRDCs that conduct early-stage research across a spectrum of scientific domains. In FY18, the labs received $12 billion in funding, yielded 1,500 inventions, and produced 700 patents [1]. The labs are operated through special M&O contracts that compete private contractors to serve national objectives.

However, reviews of the labs over the past three decades have revealed inefficiencies in DOE's operations that reduce the efficacy of the labs. The following report details the history of the national labs and the M&O contract, previous reports on the national labs, analysis, and policy recommendations.

2 Introduction

In the following sections, I discuss the Department of Energy and its mission, the role of the national laboratories, and the key problem analyzed.

2.1 Constraints & Context of DOE

The Department of Energy (DOE) is a cabinet-level agency of the US government whose stated mission is to "ensure America's security and prosperity by addressing its energy, environmental and nuclear challenges through transformative science and technology solutions."

The DOE addresses a breadth of topics, necessitating a complex organizational structure. The two commonly referred to offices are the *National Nuclear Security Administration* (NNSA) and the *Office of the Under Secretary for Science* (SC). NNSA's mission is to promote nuclear stewardship and safeguard the US nuclear stockpile, whereas SC focuses on pure scientific funding. While these are the main sources of funding for the national labs, other DOE program offices also fund the national labs, as do other government agencies.

In FY18, DOE had a budget of $34.5 billion, of which $12 billion went to the DOE's national labs [1] [2].

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2.2 Role & Purpose of National Laboratories

The US Department of Energy operates 17 national laboratories (”labs”) which aim to advance scientific discovery through federally funded research [3]. These labs are Federally Funded Research and Development Centers (FFRDCs) and are a key driver of science and technology. While the national labs research energy technologies, they also lead efforts in fundamental research, national security, and advanced computing [4]. By funding the national laboratories through targeted grants, DOE can specify research targets and thus move towards targets set during appropriations.

My analysis focuses on the 16 national labs which are contractor operated; this excludes the National Energy Technology Laboratory, which is DOE operated [5]. Additionally, much of the research provided focuses on SC laboratories, which differs from NNSA labs and labs stewarded by different program offices.

2.3 Operation of National Labs

The labs are operated through Management & Operating (M&O) contracts, which follow the Government-Owned, Contractor-Operated (GOCO) model. GOCO contracts have a philosophy of separation between the stewarding agency and the operating contractor: essentially, the agency should set the objectives while contractors set process. When executed properly, the GOCO model reduces cost for the government while improving performance, as poorly performing contractors can readily be replaced through a compete process.

The GOCO model is in contrast to the Government-Owned, Government-Operated (GOGO) model, where the government directly operates the facility. GOGO is common in the military (i.e. military bases), though there are GOCO national labs with a national security focus (i.e. Sandia National Labs).

2.4 Problem Statement

As an intern at the national lab, I always found the funding and organizational structure of the national labs to be nebulous: how *are* taxpayer dollars being funneled to my salary? Is this an effective use of funds in comparison to, for example, universities?

There are other aspects that could be investigated when considering lab effectiveness, like talent acquisition, ease of funding for research, or ease of commercialization. However, I focus my research on the M&O contract because it defines the interactions and flow of funding from the DOE to the contractor and national lab.

Last, much of my research focuses around Office of Science labs which have subtle management differences from other national labs, namely those operated by NNSA (which have a national security focus) and other DOE program offices, which may have environmental or nuclear remediation focuses.

I are interested in evaluating the M&O model in operating the national laboratories. Specifically, what changes should be made to the M&O model on both the DOE and contractor side. My recommendations aim to ensure greater oversight, alignment with national research priorities, and effectiveness of GOCO labs.

3 Operating National Laboratories

3.1 M&O Model in Brief

The Management and Operating (M&O) model was formalized during WWII, with contractors under the US Army Corps of Engineers manufacturing the atomic bombs [6]. This significant achievement by a private entity provided strong evidence for increasing the use of contractors; so, DOE adopted the M&O model with the labs. This model of contracting was innovative at the time because it embodied a shift in mentality: instead of contracting for research, DOE contracted for *management* of research [7].

The M&O model relies upon operating principles of GOCO contracts [7] [8]. Primarily:

1. DOE decides the *what* of the labs - objectives, deliverables, and targets.
2. Contractors decide the *how* of labs - processes, management, and techniques from the private sector.
3. DOE trusts contractors enough to allow experimentation while maintaining accountability for failures.

At present, the M&O model binds DOE with a contractor to operate a national lab. The binding contract, known as the *prime contract*, assumes a *base period* of five years (typically) alongside some number of *option periods* which can extend the contract. This provides flexibility and assurance in the contract: poor performance should cause termination at the end of the base period, while good performance allows for many years of operation without competition. After all options have been exercised, most M&O contracts expire due to the Competition in Contracting Act of 1984 (CICA), thereby leaving the associated lab up for *full competition* of contractors.

The M&O is a Cost Plus Incentive Fee contract (CPIF), which permits contractors to reimburse all allowable costs underneath a maximum cost while also receiving an incentive fee [9]. Pure cost-reimbursement contracts have little to no profit; in fact, CPIF contracts can easily incur accidental costs to the contractors. In my interview with Dana Storms, Prime Contract Manager at PNNL, she mentioned that any costs that Battelle incurred accidentally for projects not explicitly under the scope of the prime contract *would not be reimbursed*. Thus, the incentive fee is necessary to provide an opportunity for profit while also mitigating the risks of operating the contract.

These incentive fees are dependent upon DOE's performance assessments and are a percentage of the set performance fee. The fees are calculated given three factors: the *base performance fee*, *Science & Technology (S&T)* rating, and *Management & Operation* rating. The ratings are scaled and then multiplied, to yield the base fee:

$$F = b \times m_{ST} \times m_{MO}$$

In the example above, F is the final fee, b is the set performance fee, m_{ST} is the S&T multiplier, and m_{MO} is the M&O multiplier

These multipliers are tiered and range from 0% to 100%; thus, poorly performing contractors on either S&T or M&O can receive little to no fee. These multipliers are produced annually through the *Laboratory Appraisal Process* conducted by DOE Office of Science, beginning with a letter grade that is scaled to the multiplier.

3.2 Performance Evaluation & Fee Structures

The Laboratory Appraisal Process is an annual review of the labs that analyzes eight core *Performance Goals* as designated by the Office of Science [10]:

1. Mission Accomplishment (Delivery of S&T)
2. Design, Construction and Operation of Research Facilities
3. Science and Technology Project/Program Management
4. Leadership and Stewardship of the Laboratory
5. Integrated Environment, Safety and Health Protection
6. Business Systems
7. Facilities Maintenance and Infrastructure
8. Security and Emergency Management

Performance Goals 1-3 determine the S&T score, while Performance Goals 5-8 determine the M&O score. Performance Goal 4 is a major component of both scores, comprising 25% of the total S&T / M&O final scores. The scores are essentially grades, with an "A+" ranking warranting a score of 4.1-4.3 while an "F" grade warrants a score of 0.0-0.7. In order to compile the scores, two different approaches are used:

1. The S&T score is determined by individual DOE offices and other government agencies (i.e. NIH) that contribute to the lab and is weighted by funding. For example, a subagency providing 50% of funding for a national lab has scores that are worth 50% of the total S&T score.
2. The M&O score is determined through a combination of DOE headquarters evaluation and the regional DOE evaluation. Regional DOE offices serve as immediate "outposts" for DOE staff to closely work with lab staff, whereas headquarters sets longterm project goals. Additionally, M&O criteria have the potential to incur serious penalties given significant violations in Occupational Safety and Health (OSHA). These penalties can be assessed through fines and score penalties.

Both the S&T and M&O scores are then scaled into the incentive fee multipliers. The table mapping scores to multipliers is shown below (Appendix J of PNNL's Prime Contract) [11]:

An important aspect to note about the table is the purposeful bundling of the M&O fee multipliers: all final scores from 3.1-4.3 in the M&O category warrant the same multiplier. This plateaued fee structure is intentional - reports by GAO found [12]:

> According to DOE officials, this structure is meant to encourage contractors to reinvest cost savings into technical performance rather than improving administrative systems that already meet expectations.

Overall, the final score to multiplier table has been carefully crafted to demonstrate SC's priority of scientific achievement and advancement of "Big Science" systems while maintaining adequate administrative systems.

While the process of mapping subagency scores to final multipliers is well-described, the internal processes used to generate subagency S&T scores is obfuscated. This confusion persists into M&O scores, as many regional offices have limited safeguards to prevent more favorable ratings [12]. Simply put: there is little information on how subscores for both S&T and M&O are generated given data. As a result, concerns of bias follow.

<table>
<tr><th>Overall Final Score for either S&T or M&O from Table C.</th><th>Percent S&T Fee Earned</th><th>M&O Fee Multiplier</th></tr>
<tr><td>4.3</td><td rowspan="3">100%</td><td rowspan="3">100%</td></tr>
<tr><td>4.2</td></tr>
<tr><td>4.1</td></tr>
<tr><td>4.0</td><td rowspan="3">97%</td><td rowspan="3">100%</td></tr>
<tr><td>3.9</td></tr>
<tr><td>3.8</td></tr>
<tr><td>3.7</td><td rowspan="3">94%</td><td rowspan="3">100%</td></tr>
<tr><td>3.6</td></tr>
<tr><td>3.5</td></tr>
<tr><td>3.4</td><td rowspan="4">91%</td><td rowspan="4">100%</td></tr>
<tr><td>3.3</td></tr>
<tr><td>3.2</td></tr>
<tr><td>3.1</td></tr>
<tr><td>3.0</td><td rowspan="3">88%</td><td rowspan="3">95%</td></tr>
<tr><td>2.9</td></tr>
<tr><td>2.8</td></tr>
<tr><td>2.7</td><td rowspan="3">85%</td><td rowspan="3">90%</td></tr>
<tr><td>2.6</td></tr>
<tr><td>2.5</td></tr>
<tr><td>2.4</td><td rowspan="4">75%</td><td rowspan="4">85%</td></tr>
<tr><td>2.3</td></tr>
<tr><td>2.2</td></tr>
<tr><td>2.1</td></tr>
<tr><td>2.0</td><td rowspan="3">50%</td><td rowspan="3">75%</td></tr>
<tr><td>1.9</td></tr>
<tr><td>1.8</td></tr>
<tr><td>1.7</td><td rowspan="7">0%</td><td rowspan="7">60%</td></tr>
<tr><td>1.6</td></tr>
<tr><td>1.5</td></tr>
<tr><td>1.4</td></tr>
<tr><td>1.3</td></tr>
<tr><td>1.2</td></tr>
<tr><td>1.1</td></tr>
<tr><td>1.0 to 0.8</td><td>0%</td><td>0%</td></tr>
<tr><td>0.7 to 0.0</td><td>0%</td><td>0%</td></tr>
</table>

Figure 3. Performance-Based Fee Earned Scale

3.3 Relationship between DOE and Contractors

3.3.1 Summary

As mentioned in the discussion of the GOCO model, the DOE sets the *What* of the program (e.g. goals and performance metrics), while contractors set the *How* of the program (e.g. processes, operations).

Organization	Provides	Receives
DOE	Goals of lab, "notable outcomes," funding	Management of lab
Contractor	Private sector knowledge, expertise, talent retention, buffer between government regulations	Ability to manage lab, potential for profit

Table 1: Summary table of the relationship between DOE and contractors.

3.3.2 DOE

DOE provides direction for each lab. This is set through *notable outcomes* (measurable goals) that affect both the S&T and M&O multipliers. Notable outcomes are compiled separately:

1. **S&T notable outcomes** are set by subagency staff (e.g. SC program offices) and reflect both national priorities and general interests by the broader scientific community.
2. **M&O notable outcomes** are set by regional offices and DOE headquarters.

Each notable outcome lies within an Objective that is assigned to a specific Performance Goal (detailed in 3.2). Notable outcomes are negotiated when creating/amending the prime contract, while overall DOE targets are set through the laboratory planning process [13]. These outcomes are tightly linked to the lab's *core capabilities* and often assist in strengthening a core capability or creating a new one.

Tables 2 and 3 detail sample S&T notable outcomes and M&O notable outcomes from different prime contracts [11] [14]. Each notable outcome is attributed to a supervising agency to ensure that progress has been met; additionally, notable outcomes span a broad range of outcomes, from preparing reports, implementing plans, or correcting managerial flaws.

Nat'l Lab	Funding Agencies	Sample Notable Outcome
FNAL	HEP	*HEP: Working with OHEP, and taking into account Laboratory Optimization guidance, deliver and begin to implement a Cosmic Frontier Strategic Plan by March 2019 that builds on the laboratory's core capabilities in this area. (Objective 3.1)*
PNNL	Many: e.g. ASCR and BES	*BES: Develop an updated comprehensive strategic plan for the expanding materials research portfolio supported by BES-MSE, including considerations of supporting capabilities and instrumentation. (Objective 3.1)*

Table 2: Sample S&T notable outcomes
FNAL - Fermi National Accelerator Laboratory; PNNL - Pacific Northewst National Laboratory; ASCR - Advanced Scientific Computing Research; BES - Basic Energy Science

Nat'l Lab	Regional Office	Sample Notable Outcome
FNAL	FSO	*FSO/SC: FRA must ensure successful project and procurement management for all projects, in particular LBNF/DUNE and PIP II. (Objective 4.2)*
PNNL	PNSO	*PNSO: Implement the new line management approach to increase management accountability as part of a multi-year plan to implement the proposed new operating model at PNNL. (Objective 4.2)*

Table 3: Sample M&O notable outcomes
FSO - Fermi Site Office; PNSO - Pacific Northwest Site Office

3.3.3 Contractor

M&O contractors ensure smooth leadership of national labs, maintain facilities, and attract talent that otherwise would not be attainable through government-run labs. Simply put, they nurture a unique culture to serve the federal government while building a buffer from bureaucracy.

Because CPIF contracts reimburse only for work explicitly under the prime contract, it's unsurprising that contractors work hard to persistently ensure they are executing DOE's wishes. Contractors are in constant contact with their site offices to ensure work is under scope and aligned with DOE headquarters' priorities.

Additionally, M&O contractors are given additional discretion with overhead funds. Namely, extra overhead can be used for Laboratory Directed Research and Development (LDRD) projects that will advance the lab's score in S&T. Contractors are expected to prudently deploy LDRD funds in order to contribute to outputs listed above (namely scientific discoveries). LDRD funds also attract junior scientists, as they provide an easier funding source that is limited to laboratory scientists.

3.4 Outputs of the National Lab

The labs produce a range of outputs, including:

1. **Scientific discoveries** through publications.
2. **Commercialized technologies**, through patents and commercialization programs.
3. **Investments into major scientific facilities**, which are open to institutional and private partners. These major scientific facilities are commonly known as 'big science' projects.
4. **Strategic Partnership Projects** (SPP), which enable labs to perform work on behalf of other government agencies, universities, or other entities.

4 Analysis

4.1 DOE's Role in Contracts

The following section analyzes issues related to DOE's operations in contracts, including compete cycles, DOE / site office interactions with contractors, and other aspects of how DOE manages M&O contracts.

4.1.1 Laboratory Appraisal Process

The incentive structure, and how DOE leverages it to influence contractors, is the crucial underpinning of the DOE-contractor relationship. The Laboratory Appraisal Process (LAP) is how labs are assessed along the eight Performance Goals (3.2) and how incentive fees are awarded.

While the criteria provided by SC is complete, there are two main concerns with the LAP [12] [15]:

1. **Objectivity** - Even with the current level of competition, historical studies cast doubt onto the objectivity of evaluators. For example, there are concerns that ratings are inflated and that evaluators are too closely aligned with contractors and lab employees. Notably, reports acknowledge that site offices are expected to interact with the labs they supervise on a near-daily basis, then subsequently review them during the LAP.

2. **Lack of clarity in appraisal process** - Labs are expected to conduct numerous reviews, but there is a lack of clarity in the path from report to reader. Specifically, how SC suboffices integrate these reviews is difficult to discern (3.2). Additionally, contractor deliverables include many reports, but there is significant opacity into whether reports are actually considered by site offices and DOE HQ.

The scope and severity of these factors is unclear because of the opacity of the evaluation process to the general public: it's reported that program offices use normalization to prevent inflation and take a holistic approach when reveiwing contractor performance. Greater investigation is necessary to identify the potential effects on the LAP's efficacy in fairly rewarding incentive fees, aligning contractors to national priorities, and triggering compete cycles.

4.1.2 Competition

A critical aspect of the GOCO model is the presence of competition. In contrast to the GOGO model, GOCO models are theorized to leverage competition to transform non-markets into markets, thereby introducing benefits of markets (e.g. increasing allocative efficiency) [16].

Competition directly underlies M&O fee structures. SC laboratories operate without fixed fees, meaning that the only "profit" made is through performance-based incentive fees. This is possible because nonprofit organizations typically hold strong values of scientific discovery and national service over profit motive when operating SC labs. For example, Battelle, a major operator of national labs, quotes their founder in their values [17]:

> Translate scientific discovery and technology advances into societal benefits ". . . for the purpose of education in connection with and the encouragement of creative and research work in the making of discoveries and inventions . . . to do the greatest good for humanity . . ."

This quote embodies the value sets of many science nonprofits: leverage science for the common good. Similarly, SC labs are focused broadly on basic research or research that advances the economy; these labs are rarely involved with weapons development or controversial research.

In contrast, NNSA labs have a strong focus on weapons development and other national security applications. Because of this military specialization, I imagine many nonprofits would be wary of pursuing projects that likely conflict with their value sets. This adversely affects supply of contractors for these labs, decreasing competition and requiring NNSA to provide a fixed fee in addition to incentive fees.

To implement competition, DOE is in accordance with the Competition In Contracting Act (CICA). With the adoption of CICA, DOE has expanded the use of competition, mostly in the early 2000s and 2010s; currently, seven of the ten Office of Science laboratories have had their contracts competed in the past two decades. Reports suggest that competition, even among nonprofits, can often induce efficiency [7].

Compete cycles are not without costs: for contractors, the process of preparing bids can cost between $3 and $5 million [15]. For DOE, compete cycles require about about 18 months of staff time to adequately prepare and execute the compete process [18].

These costs have raised concerns within DOE over the efficacy of competes and the optimal frequency of usage. Additionally, DOE holds concerns that the process of transitioning labs between contractors is fundamentally disruptive to both staff members and lab performance [15], a viewpoint supported by existing research on compete cycles and performance [19]. The degree of integration between performance ratings and compete cycles is unclear; prior research indicates that these ratings are disconnected from triggering compete cycles [15].

The optimal frequency of competition is beyond the scope of this research; however, GAO and DOE do note the importance of competition as leverage over contractors. Award terms (or the threat to leverage a compete cycle) on the prime contract serve as powerful inducements to force contractors to change procedures or policies to align with DOE goals.

4.1.3 Incentive Fees

Even though many M&O contracts use CPIF structures, which purport to provide no guaranteed fee for contractors, performance appraisals do not reflect this intuition. Notably, contractors almost always receive extraordinarily high portions of their incentive fee - from FY 2006-2016, contractors received **94%** of the incentive fee, on average [12]. This is a huge proportion of the incentive fee that corresponds to near perfect performance on every S&T and M&O target.

The incentive fee can be characterized as an implicit fixed fee: if contractors know that they have been historically granted huge portions of their incentive fees, they can plan around a conservative estimate of the amount of the fee they'll receive (say, 80%); a performance score above this threshold is simply an additional benefit. This disincentivizes contractors from truly caring about performance, as simply maintaining existing performance (or even allowing for it to degrade) will still yield the implicit fixed fee.

4.2 Lab Deliverables

This section is dedicated to exploring the output of the labs. It will not be a comprehensive cost-benefit analysis; rather, I focus on compiling analysis in other literature. Additionally, the underlying value set is one of economic contribution and scientific discovery: my lens prioritizes projects which either have measurable social or economic ROI, or yield significant scientific advances.

Because the labs deliver a broad spectrum of deliverables, a similarly broad spectrum of metrics are used under each category. I return to the original classification of deliverables found in 3.4 and analyze each based on existing literature.

4.2.1 Scientific Output

Scientific output refers to publications and scientific discoveries. There are two underlying metrics used to assess output:

1. Publication count, or number of articles accepted by peer-reviewed journals, represents the number of discoveries made by researchers

2. Citation count, or number of times publications have been cited by other scientists, signals the importance of discoveries made by researchers.

These metrics are supplanted by other metrics, like h indices, which are derived from citation count and publication count; H indices are presumed to be more accurate indicators of output and are easier to compare within fields.

When comparing by h indices, the national labs show strong performance; Figure 1 compares DOE lab indices to public universities, top ranked universities, and NASA. The figure demonstrates that national labs have indices that are consistently comparable to public universities and are sometimes on par with top ranked universities [20]. In sheer publication count, the labs produced a total of 11,000 peer-reviewed publications in 1,500 journals in FY15 [21].

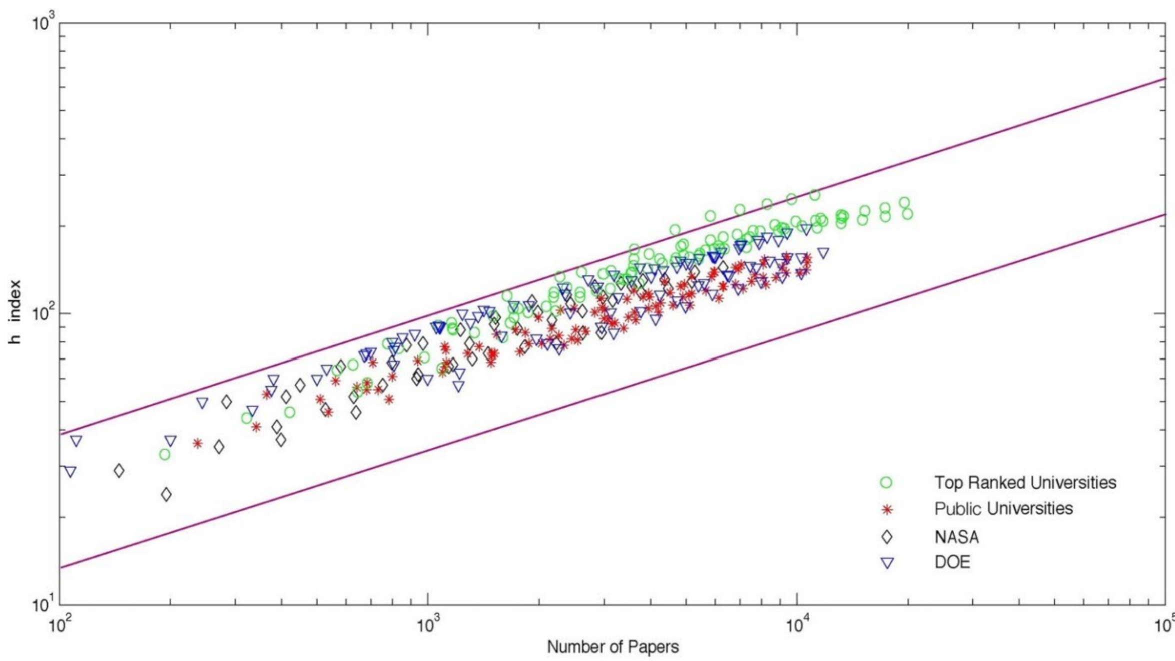

Figure 1: Table from [20] demonstrating h indices across top ranked universities, public universities, NASA, and DOE.

While there are arguments against the validity of using h indices and citation, overall these results suggest that labs have scientific output comparable to other major research institutions that are public, private, or government run.

It's important to note that labs also provide research for national security applications that would be difficult to obtain through the public or private spheres. While some universities have military grant status, the default is towards transparancy and public research; in contrast, private R&D is often profit focused and fails to advance high risk research. Because the labs were formed to create the atomic bomb, they have an enduring legacy of classified research; moreover, programs similar to academia (like LDRD grant programs) serve as compelling mechanisms to retain top talent that would otherwise pursue open research at universities. Thus, the labs provide a medium towards investment in long-term, high-risk classified projects while maintaining talent that would otherwise work in academia.

4.2.2 Commercialized Technologies

The labs have variable levels of success in producing patents versus the private sector when comparing by cost per patent: the average cost per patent of relevant industries is \$4.5 million, whereas in the national labs the cost is \$7.6 million. However, the cost per licensed patent is \$64 million for relevant industries, whereas in the national labs the cost is \$16 million [1].

These results are consistent with the context of national labs: the labs invest in basic research, which is often fruitless from a patent perspective, while focusing on medium and high risk research, which has a greater risk of failure. Both of these factors drive up the cost of patents. The reduced cost per licensed patent could be explained by niche patents or streamlined patent licensing programs.

Technology commercialization is also integrated into prime contracts: it's set as a priority (Performance Goal 6, Objective 5) and labs are expected to interact with DOE to run technology transfer programs. However, commercialization is not a heavy priority: in the prime contract, commercialization is only 10% of the total score for Performance Goal 6, or up to 1.9% influence of the total M&O final score. In essence, a total failure in the commercialization score could cause no effect on the M&O multiplier.

This deprioritization is somewhat reflected by patent revenues - while the licensed patents had a lower unit cost, they also had a lower average patent income of \$109,000. This is a stark contrast to private sector averages, which hover around \$10 million per patent [1].

I attribute the significantly reduced patent income to two factors:

1. **Specialization of research**: labs often invest in highly specialized research tied to core capabilities. Thus, patents may be critical, but niche, advancements that do not have broad markets to increase per patent revenue.

2. **Lack of focus on profit**: contractors are not heavily incentivized to prioritize strong revenues from patents. The incentive fee itself is relatively unaffected by major increases in performance in tech commercialization programs; additionally, resources may be better spent at other aspects of the lab.

These patents may also stimulate the economy by providing a technical advantages to US companies at low cost. While this economic analysis is outside the scope of the report, it's an important consideration given the breadth of patents obtained and licensed by the labs.

4.2.3 User Facilities

User facilities are large scientific apparatus available to both DOE scientists and scientists from other institutions. These facilities are often multi-million or multi-billion dollar projects that run for decades ("Big Science"). Researchers at public institutions with approved proposals can access user facilities free of charge, while "full cost recovery is required for properietary research" [22]. Notable examples include the National Energy Research Scientific Computing Center (a supercomputer for energy simulations), the Advanced Photon Source (a particle accelerator) and the Environmental Molecular Sciences Laboratory (a large scale laboratory with specialized computational and molecular chemistry technology).

In FY15, there were 27 user facilities with over 32,000 users (or external scientists), 80% of which were at US institutions [22]. User facilities are accounted for in the S&T Performance Goals, mostly within "Design, Construction and Operation of Research Facilities" (Performance Goal 2). Thus, some labs prioritize the maintenance and construction of user facilities, while others eschew the large-scale projects for more projects without major funding requirements.

There are limited private alternatives to these user facilities, especially given the low cost for researchers. They often serve as the only option for researchers to cheaply access world-class scientific instruments. The economic impact is uncertain; however, a multitude of government, public-, and private- sector entities use these user facilities. Again, we see that these facilities may provide significant implicit economic benefits to companies, though further studies are warranted.

4.2.4 Strategic Partnership Projects

Limited information is available about SPPs, as much of the work is classified and involves military material. The DOE report on SPPs states [23]:

> SPP customers at SC laboratories include private companies (foreign and domestic), universities, other Federal government agencies, and state and local institutions. In FY 2008, SC laboratories received approximately $701.3 million of SPP funding and an additional $314.1 million of DHS funding.

DOE also specifically notes the role that SPPs have within labs' overall mission:

> For these reasons, SC pays close attention to the overall amount of SPP an SC laboratory expects to conduct in any given year relative to its total budget, and even more attention to any laboratory whose SPP program approaches or exceeds 20% of the laboratory's total operating budget.

This scrutiny is indicative of SC's priority in maintaining DOE oriented R&D - if a lab is taking on a significant level of SPPs, this signals to DOE that SC program offices find less value in the lab than other government partners.

As for the prime contract weight, SPPs fall within "Leadership of External Engagements and Partnerships" (Performance Goal 4, Objective 3), which accounts for 10% of the total weight of Performance Goal 4 (up to 2.5% of both the S&T and M&O multiplier final scores).

In essence, SPP funding is small, but creates large impacts outside of the labs. SPPs leverage lab resources to support government or private sector endeavors in more cost efficient manners than possible through academia or GOGO labs.

4.2.5 Summary

In sum, national labs provide a number of outputs that implicitly benefit the US economy and government. Scientific output is on par with public universities; tech commercialization may provide cheap access to crucial patents; user facilities advance basic research and provide low-cost access to world class facilities; SPPs provide benefits to other government agencies and directly supports private entities with lab resources.

4.3 Management Deliverables by Contractors

In contrast to 4.2, expectations for management are concrete and have analogs in both the public and private sectors. I analyze core obligations of the contractor in managing the lab. I do not analyze the effectiveness of managing classified material or other procedures for sensitive information, though this is implicitly included through sources cited.

4.3.1 Occupational Safety and Health

Numerous factors of the labs' work adds complexity to the regulatory labor landscape: work may be sensitive or classified in nature, land is government owned but sites are scattered across states with varying labor laws, and employees exist in a duality, as they are both federal employees and contractors. Moreover, Occupational Safety and Health (OSH) is factored into the prime contracts as "Provide an Efficient and Effective Worker Health and Safety Program" (Performance Goal 6, Objective 1), accounting for up to **14.6%** of the final M&O score. Because OSH plays such a critical role both from a regulatory and monetary standpoint, intensive audits, reviews, and reports follow.

The result is a confusing system where jurisdiction is shared among the Department of Labor, DOE, and state and local governments. While OSHA and DOE have a Memorandum of Understanding yielding jurisdiction to DOE on government owned sites, contractor owned sites fall under OSHA or OSHA-approved State Plans. This results in a significant amount of duplicated requirements across the different regulatory bodies. A group of lab contractors commented on the severity of the system [8]:

> [W]e recommend that the Department eliminate all requirements that duplicate or supersede other federal or state requirements, thereby simplifying requirements management, eliminating confusion caused by multiple regulators overseeing the same function, and eliminating redundant audits.

While the system may be confusing, it has been effective at maintaining OSH. For minor accidents, Total Recordable Case (TRC) rates are only slightly above averages in other scientific companies (0.97 vs 0.8), which could be attributable to the experimental nature of research and additional proximity to nuclear material [24] [25]. In terms of large scale accidents, there have been few public failures in employee safety and health: from FY06 to FY16, the total penalties DOE assessed to contractors amounted to only $54.22 million, a small portion of the total fees granted to contractors over the timespan [12]. For NNSA labs, DOE can also suspend fixed fees in addition to incentive fees, a powerful inducement to ensure safety.

4.3.2 Leadership

Contractors are expected to create a culture that is conducive to scientific discovery. A strong culture is critical for talent retention, as labs are vying for scientists who can also work in academia, where tenure is granted, or the private sector, where compensation is much stronger. Furthermore, contractors must carefully watch *their own* culture; from the founding of the labs, early labs had radically different cultures that were imparted by the contractor itself [26].

Contractors are also expected to demonstrate a comprehensive vision for the lab. “Leadership and Stewardship of the Laboratory” (Performance Goal 4, Objective 1) has a top rating with the following expectation:

> The Senior Leadership of the laboratory has made significant progress over the previous year in realizing their vision for the laboratory, and has through this has had a demonstrable positive impact on the Office of Science and the Department. Strategic plans are of outstanding quality, and recognize and reflect the vision/plans of other national laboratories. Faced with difficult challenges, actions were taken by the Senior leadership of the laboratory to redirect laboratory activities to enhance the long-term future of the laboratory. Partners in the scientific and local communities applaud the laboratory in national fora, and the Department is strengthened by this.

This goal is ambitious: it requires concrete and compelling strategic plans where contractors build out core capabilities while effectively catering to DOE’s needs. In addition, it reflects DOE’s long-term priorities, as the government still owns the facilities.

Because of the complexity of these tasks, contractor leadership and vision constitutes a major part of the incentive fee. Leadership is reflected by Performance Goal 4.0, which accounts for up to 25% of both the S&T and M&O scores. Thus, contractor leadership deemed unsatisfactory by DOE can easily result in significant reductions in incentive fee, in addition to the potential for a compete cycle.

4.3.3 Reviews and Reports

Contractors are expected to provide a host of reports and memos to DOE throughout the contract. For example, PNNL’s prime contract stipulates nine letters as deliverables to DOE, many of which recur monthly, quarterly, or annually [11]. These contracts address a breadth of issues, from internal DOE protocol, policies from OMB, and requests for updates from leadership. Whether these reports are onerous is disputed, especially because DOE maintains oversight of contractors throughout the GOCO process.

5 Recommendations

The following sections are comprised of recommendations that address topics mentioned in Section 4 alongside respective concerns for implementation.

Overall, the labs have strong output and a well-defined incentive system to ensure optimal performance of contractors (and competition when necessary). The following recommendations are adjustments to M&O contracts and DOE behavior to further optimize the existing framework.

5.1 Actions to Reform Contract Clauses

The following recommendations center around changes to the M&O contract to improve performance. The CPIF structure should be maintained, as current contractor performance is strong and recent research suggests that these contracts are cheaper than alternatives for complex tasks like lab management [27]. Additionally, the contracts were cleared of major faults during comparisons to other FFRDCs [28]. My recommendations center around the incentive fee award process and performance evaluation processes.

5.1.1 Review Scoring Criteria

The current scoring criteria has served the national labs well, but there are some notable deficiencies - for instance, prioritizing technology commercialization could allow for greater patent output in the national labs.

> **Recommendation** *Using existing strategic plans for the national labs, review and reweight the M&O criteria to better prioritize present objectives. Ask for input from contractors, scientists, and other staffers while recalibrating the weights.*

By recalibrating the weights, DOE can indicate and clarify its expectations from contractors. Additionally, these renewed evaluations will provide an updated metric on whether the current contractor fits DOE's mission (and if a compete cycle should be leveraged).

> **Concern** *This process will require a significant time investment from senior DOE officials and needs careful consideration to prevent abuse by contractors; maintaining the status quo may be taken out of expedience rather than effectiveness.*

5.1.2 Rectify Appraisal Process

When considering the value set of the appraisal process, DOE should prioritize integrity and accountability. The current appraisal process routinely awards high grades ("Exceptional") that do not hold their stated meaning. This causes incentive fees provided to be inflated. As said by GAO [12]:

> In reviewing DOE's M&O contractor performance evaluations for fiscal years 2006 through 2016, we found the results of the evaluations to generally include high performance ratings and most available performance incentives, including a median of 94 percent of available award and incentive fees. During this time frame, administrative performance sometimes had lower ratings—though these were balanced out in overall ratings by strong performance elsewhere—and some safety issues and accidents resulted in additional fee reductions outside the performance evaluation process.

Per DOE's guidelines, 94% represents performance ratings of Excellent or Very Good for almost every category of evaluation, meaning that contractors meet or exceed expectations for nearly every category. While it is not anomalous for contractors to exceed expectations, consistent ratings that exceed expectations implies expectations that are not ambitious enough (or lab planning processes that are overly pessimistic).

> **Recommendation** *Rescale laboratory evaluations to set B/B+/A- ratings as 'meeting expectations' and A/A+ ratings as 'exceeding expectations.'*

> **Recommendation** *Rescale S&T multipliers to bring B/B+ ratings closer to 80-90% and scale lower grades accordingly*

This recommendation is in contrast to current DOE language [10]:

> A grade of "B+" is awarded for performance at the Objective level that meets SC's expectations for performance. SC intentionally set its expectations associated with a B+ very high, and does not equate performance below a B+ as necessarily unsatisfactory, but as offering opportunity for improvement.

By adjusting recommendations downwards, contractors will be rewarded with smaller percentages of the incentive fee even if grades are inflated.

To address overly pessimistic planning, I suggest changes in the lab planning process:

> **Recommendation** *Evaluations with "exceeds expectations" should trigger internal DOE reviews that adjust expectations and notable outcomes.*

By forcing automatic rescaling of expectations whenever high ratings are given, the lab planning process can be redirected towards giving more 'meets expectation' grades.

> **Concern** *While these changes may re-calibrate performance evaluations, they also weaken DOE's position politically. Congress is less likely to appropriate funding when the labs only have satisfactory performance. Furthermore, these recommendations are nebulous and difficult to enforce.*

5.1.3 Address Contracts that are Implicitly Fixed Fee

When contractors are implicitly given fixed fees through performance evaluations that perpetually remain high, these incentives lose their intended effect: rewards that scale to performance. To solve that, I propose:

> **Recommendation** *Modify fee structures to reward exceptional performance sparingly yet provide guaranteed fees.*

To accomplish this recommendation, the following fee structure could be implemented:

1. **Introduce a fixed fee** that may only be revoked in cases of extraordinarily poor performance. This fixed fee will allow private contractors to take on the risk of management, especially given the cost of competing for contracts (4.1.2).
2. **Leverage the incentive fee for exceptional performance**, for example when projects are completed below budget or when stretch goals are achieved. This realizes the intention for incentive fees to be achievement oriented.

By introducing a guaranteed fixed fees, there will be 1) an increase in competition as for profit contractors bid for SC labs and 2) present contractors are given additional leeway to experiment without risk of damaging crucial revenues.

This recommendation is aimed at Office of Science labs and integrates processes NNSA labs already use - for example, Los Alamos National Laboratory's contractor, Triad National Security, LLC, received more than $43 million in fees, $20 of which was fixed fees [29].

Furthermore, this recommendation is consistent with changes suggested 5.1.2. Ratings centered around B-/B/B+/A- should warrant mostly fixed fees, while A/A+ ratings yield significant incentive fees.

Concern *Introducing too large of a fixed fee disincentivizes additional effort to achieve extraordinary performance; without proper changes to the appraisal system, this new funding model could unnecessarily increase costs.*

Concern *Private contractors may impart a culture that prioritizes profit over scientific discovery and service, damaging the reputation of the lab and talent retention.*

5.1.4 Use of Reputation Incentives

Additionally, other incentives can be provided to improve contractor performance. For example, reputation:

Recommendation *Expand the use of public evaluations, for example by publishing all Performance Evaluation Reports (PERs).*

While NNSA publishes summaries of PERs for their labs, the Office of Science only provides the scorecard of their stewarded labs. This obfuscates where labs failed and on which measures. By providing detailed PERs, managing contractors have the quality of their work reflected publicly.

Concern *Publishing PERs may require administrative overhead to screen for sensitive information.*

5.2 Actions for DOE to Increase Output

While the labs produce a series of outputs, there are areas where they fall short. The following recommendations are aimed at DOE to better support contractors with these areas.

5.2.1 Prioritize Commercialization and Tech Transfer Programs

The lackluster per patent revenue detailed in 4.2.2 could be attributable to the labs, but they may also be attributable to poor commercialization resources on DOE's side. In fact, the historical trend for DOE commercialization revenue has been downwards: patent revenue from FY10 to FY14 declined by almost $3 million, representing a 6.8% decline in revenue. This comes as the number of patents issued annually to the labs increased by 44.4% in that same time period.

Recommendation *Invest in existing tech commercialization programs to better convert existing patents into leverageable technology for the general economy.*

Recommendation *Strengthen inter-government patent licensing, especially to relevant military or biomedical agencies.*

By pursuing greater licensing of patents both within and outside the US government, lab discoveries can broaden their immediate impact on American lives and communities.

Concern *DOE may not have the technical expertise to cheaply implement large scale commercialization programs that interact with individual labs; too heavy of a focus on patents (rather than scientific discovery) may come into conflict with core DOE values.*

Concern *Patents obtained may be too niche or select to warrant large revenues.*

5.3 Actions to Bolster Long Term Lab Funding

From the public's perspective, the entirety of information about the labs is through DOE's performance ratings and news on scientific output. This is not sufficient when justifying a huge civilian workforce and federal expenditure. These recommendations focus on fomenting the political position of DOE to ensure continued funding.

5.3.1 Encourage Community Engagement

Currently, engagement with the community where the lab is located plays no role in the incentive fee. A direct approach to solving this is integrating community outreach to the appraisal process:

> **Recommendation** *Require lab strategic plans to contain a community outreach component. Ensure laboratory leadership present a vision that encompasses the lab's relationships with the surrounding economy.*

Integrating this recommendation would be relatively straightforward, simply requiring evaluations from DOE. Additionally, this would directly incentivize contractors to interact with their community. However:

> **Concern** *Lab leadership may not follow through on community outreach, as it would be a secondary priority; this could be seen as an overreach by DOE in nonobservance of the GOCO model.*

While requiring engagement with the community may be overreach by DOE, a DOE-led approach could strengthen outreach efforts:

> **Recommendation** *Delegate funds to site offices to encourage opportunities for community engagement, including mentorship programs with local students or collaborations with K12 educators.*

Site offices often reflect the communities of labs, as they are geographically closer than DOE headquarters. Providing discretionary funds for site offices may allow for targeted regional initiatives that build trust and political support in the community.

> **Concern** *There are costs associated with these recommendations that may be better spent on core science initiatives; community engagement work may be better suited for other federal agencies, like the Department of Education.*

5.3.2 Implement Annual Reviews

In 2017, DOE released its first annual report on the state of the national labs [21], directed to Congress. This report followed from recommendations provided by the Congressionally mandated *Commission to Review the Effectiveness of the National Energy Laboratories* (CRENEL). There have been no follow-up reports since, even though though then-Secretary of Energy Moniz noted:

> [CRENEL recommended that] the Department should better communicate the value that the Laboratories provide to the Nation. We expect that future annual reports will be much more compact, building on the extensive description of the Laboratories and of the governance structures that are part of this first report.

Thus, following CRENEL's recommendation:

Recommendation *Conduct annual reviews of state of all national labs annually or bi-annually to inform Congress and the public of the value of the labs.*

Given the low visibility of the labs, this effort is crucial towards ensuring continued political support.

Concern *This approach may be costly from an administrative perspective or may be less effective than directly interfacing with congressional representatives.*

6 Conclusion

The modern M&O contract is largely a product of the circumstances surrounding its inception. Effective private contractors produced the atomic bomb during WWII, paving the way for contractors to tackle increasingly ambitious government projects.

At present, the 16 GOCO DOE National Labs are operated through different stewarding agencies, mostly through SC and NNSA. SC labs have had the benefit of major nonprofit management organizations, like Battelle and UC Berkeley, to rely upon solely CPIF contracts. In contrast, NNSA labs have a national security focus and leverage both award and incentive fees to stimulate competition.

The labs produce a number of outputs, many of which have nebulous economic returns. However, from a scientific perspective, the national labs are critical: they provide resources the private sector would not, while also serving classified and sensitive research areas that the public sector would not. Additionally, the labs direct landmark intellectual property (like patents) and technical expertise directly to US companies and military through tech transfer programs. These operations are conducted with minimal risks to employee health and with marginal incentive fees to contractors.

Even with these achievements, the labs and DOE have room for optimization. Among a spectrum of issues, the appraisal process is opaque, raising questions of the subjectivity of officials when providing lab ratings. DOE also fails to launch comprehensive outreach efforts and often falls short when interacting with stakeholders outside of the direct M&O contract relationship.

To address these concerns, I recommend:

1. A reevaluation and recalibration of processes relating to the issuance of incentive fees, including rescaling score weights and considering converting CPIF contracts into dual award and incentive fee contracts
2. More evaluations by DOE into alternative ways to support contractors, including through expanded commercialization programs
3. Stronger outreach efforts on behalf of DOE to communities and policymakers in order to ensure long term funding

While these recommendations are not definitive solutions, they work to address present flaws in the M&O contract and relationship between DOE and contractors.

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