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INSTITUTIONS TO PERFORM GOVERNMENT-FUNDED R&D

A Report to NEDO

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PREFACE

The study underlying this report was commissioned by the Washington, D.C., office of Japan's New Energy and Industrial Technology Development Organization (NEDO).

The report's authors, working together as the firm of Technology Policy International (TPI), have undertaken the study as independent consultants, although it should be noted that each has other professional affiliations and activities (see "About the Authors"). The opinions expressed in this report do not necessarily reflect the views of NEDO or the institutions with which the authors are affiliated.

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Contents

INSTITUTIONS TO PERFORM GOVERNMENT-FUNDED R&D

INTRODUCTION

The United States government uses a wide variety of institutional mechanisms to perform R&D, and these mechanisms involve different degrees of government control. These range from, at one end of the spectrum, government-owned government-operated (GOGO) laboratories to, at the other end of the spectrum, competitively awarded contracts, cooperative agreements and grants to companies, universities or other non-profit organizations for individual projects. In between, there are a wide variety of models, including government-owned, contractor operated (GOCO) laboratories, Federally Funded Research and Development Centers (FFRDCs), University Affiliated Research Centers (UARCs), and a wide variety of centers, “hubs”, and other medium to long-term relationships with universities, independent research organizations, and companies[1].

This paper provides a brief overview of this large and complex topic. It discusses:

- The different kinds of R&D performing institutions, their key characteristics, and the nature of their relationship with the Federal government
- The strengths and weaknesses of different types of institutional arrangements, both for the government and for contractors
- The benefits, for the government and the contracting organizations in different types of arrangements, and why different models are used, based on the type of work or government needs
- Issues, such as managing conflicts of interest and assessing performance

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[1] This paper does not discuss the special case of large “defense contractors” that carry out large-scale weapons and other military systems development and testing projects for the Department of Defense, often with the expectation that they will later produce the resulting systems under separate procurement contracts. The same companies, along with a few other large “systems” companies, also do similar large scale non-military development projects for NASA and some other agencies. For the most part, these large contractors do not compete with the kinds of laboratories that are the focus of this paper.

It concludes with a discussion of overall trends in the use of the different kinds of mechanisms, which are generally evolving toward use of more private sector ownership and management, and more networked forms of laboratories, such as hubs and centers.

OVERVIEW OF TYPES OF INSTITUTIONS

In this paper we focus on four broad categories: [2]

- Government-owned, government-operated laboratories, staffed by federal employees
- Government-owned or affiliated, contractor-operated laboratories, in which there is a long-term, mutually committed relationship between a government agency and the government sometimes owns or leases the facilities but contractors operate the labs. There are several different variations of these laboratories.
- Independent contract research organizations (without a long-term affiliation with a government agency)
- A variety of smaller R&D organizations, including centers, R&D "hubs," and special R&D institutes

These range on a spectrum from "mostly government organizations" to "mostly private organizations" regarding their ownership, employees, and direction.

GOVERNMENT-OWNED, GOVERNMENT-OPERATED (GOGO) LABORATORIES

These are the oldest and most traditional form of government laboratories. These have a long history, dating from military arsenals in the late 18th century and research laboratories in the 19th century. Examples include the Springfield Amory (1794), the U.S. Armory and Arsenal at Harpers Ferry (1799), the research offices of the U.S. Department of Agriculture (begun when the Department was created in 1862), the U.S. Hygienic Laboratory (created in 1887 and the predecessor to the National Institute of Health's internal laboratory), the National Bureau of Standards (created in 1903 and now the National Institute of Standards and Technology), and the Langley Research Center (created in 1917 as part of the National Advisory Committee on Aeronautics and incorporated into NASA in 1958). These are staffed largely by government

[2] We focus in this paper on organizations that perform R&D for the government. Other government organizations that plan, fund, and evaluate R&D such as NSF, OSTP, and NIH are beyond the scope of this paper. Research grants to universities and medical centers are also outside of the scope.

employees and generally serve a well-defined government mission – national defense, public health, maintaining weights and measures, etc. They follow (mostly) civil service personnel rules and government management, budgeting, and accounting practices.

It should be noted, however, that while these organization are government laboratories, they are not entirely government organizations. Some may use (at least in part) leased rather than government-owned buildings, and there are increasing numbers of non-government people involved in their operations. These may include:

- Outsourced services (such as food service, maintenance, information technology)
- Outsourced technical support (technical program execution)
- Visiting researchers

As will be discussed later, there is an overall trend toward an increased use of private contractors within government agencies. Nevertheless, this category of laboratory is managed by government employees, and most of the technical staff are typically government employees.

GOVERNMENT-AFFILIATED, CONTRACTOR-OPERATED LABORATORIES

This category consists of laboratories that operate with a long-term semi-exclusive relationship with a Federal agency. This category of laboratory developed during the Second World War when it became necessary to use private organizations to provide the expertise and management skills needed to develop new weapons and other war materiel. Important examples from that period include Los Alamos National Laboratory, the MIT Radiation Laboratory (the predecessor to today's Lincoln Laboratory), and the Navy-sponsored Applied Physics Laboratory at the Johns Hopkins University.

The key characteristics of this category are:

- The laboratories are managed by a contractor and the main employees are contractor personnel, not government employees.
- There is an exclusive relationship with a Federal agency: each laboratory focuses on the needs of agency and will only work for others with the permission of the agency. There are strong regulations regarding conflicts of interests to ensure that the contractor's work for the government is not biased by other interests.
- The laboratory's relationship with the government is long-term, sometimes with no defined ending date.
- The agency can award work to the laboratory on a non-competitive basis (and consequently, laboratory and Federal employees can have open discussions about

needs and capabilities without violating procurement rules, which is generally not possible for work that is done on a competitive basis).

- The laboratories are not allowed to compete with the private sector for work.

There is considerable variation within this category and are several overlapping and somewhat confusing subcategories. Some laboratories are government-owned laboratories that are operated by a contractor, known as **"government-owned, contractor-operated" (GOCO)** laboratories. Others are non-Federal organizations that operate under a long-term contract to exclusively serve the government (sometimes referred to as "contractor-owned, contractor-operated" (COCO) laboratories. There are also some special designations that refer to laboratories established under specific laws or regulations. These include **"Federally Funded Research and Development Centers" (FFRDCs)** and **"University-Affiliated Research Centers" (UARCs)**.

The subcategories can be quite confusing because:

- GOCOs are not precisely defined (there is no official list or agreement about which labs are GOCOs).
- There is overlap between the GOCO and FFRDC subcategories. Many GOCO laboratories are also FFRDCs, but some are not. Some people consider all FFRDCs to be GOCOs, but most people consider only some FFRDC to be GOCOs (with the rest COCOs).
- The GOCO term applies not just to laboratories, but also to some weapons production facilities.
- UARCs are very similar to university-based FFRDCs.

For the purpose of this paper, these definitions matter little. What is important to note is that within this category of government-affiliated, contractor-operated laboratories, there are some common features but also some differences. Some of the laboratories are clearly government facilities that are operated by a contractor, whereas others are more like non-governmental organizations that have a long-term committed relationship with the government. But all are contractor-operated laboratories that primarily serve the government.[3]

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[3] As a further complication, some FFRDCs are essentially free-standing private entities managed as non-profit organizations under the aegis of a university, a profit-making corporation, or a consortium of universities and/or corporations, while others are set up as administrative units within a larger non-profit organization. As illustrations of the latter arrangement, the RAND Corporation administers three FFRDCs under separate DOD COCO contracts and the Battelle Memorial Institute (sometimes in partnership with other organizations) operates several DOE GOCO laboratories that also happen to be categorized as FFRDCs. Depending on the exact nature of the legal agreement between the government and the contracting entity, the latter may have substantial activities and

FEDERALLY-FUNDED RESEARCH AND DEVELOPMENT CENTERS

FFRDCs are organizations that conduct R&D or perform analyses for the Federal government. They are defined as a special category of organization in U.S. government contracting regulations[4]. (Note that there are three types of FFRDCs: research and development laboratories, systems engineering and integration centers, and study and analysis centers. Here we focus on the laboratories.) FFRDCs are established to meet long-term governmental R&D needs and have a special relationship with the government, giving them access to data, staff and facilities beyond what is available in normal contracts. In return, the FFRDC is required to operate in the public interest with objectivity and independence, to be free from organizational conflicts of interest, and to have full disclosure of its affairs to the sponsoring agency. FFRDCs are not allowed to compete against any non-FFRDC (except in the competition to operate an FFRDC). The sponsoring agency determines the conditions under which an FFRDC can accept work from any organizations other than the sponsor(s). At least 70 percent of an FFRDC's financial support comes from the Government.

There is an official list of FFRDCs, maintained by the National Science Foundation, at http://www.nsf.gov/statistics/ffrdclist/ . There are currently 42 FFRDCS. These include 26 research and development laboratories, ten study and analysis centers, and six system engineering and integration centers. Of the 42, 16 are sponsored by the U.S. Department of Energy (these are all GOCO R&D laboratories, and include all of the major DOE national laboratories). 10 are sponsored by the Department of Defense, 5 by the National Science Foundation, 3 by the Department of Homeland Security, 2 by the Department of Health and Human Services, and 6 agencies sponsor one FFRDC each.

FFRDC vary greatly in size. Fiscal year 2013 R&D expenditures at FFRDCs ranged from $5 million for the Science and Technology Policy Institute, managed by the Institute for Defense Analysis, to $2.4 billion (500 times greater) for the Sandia National Laboratory, managed by the Lockheed Martin Corporation.[5]

There are some substantial differences between the operations of Department of Energy FFRDCs and the others. The DOE FFRDCs operate under a specific type of contract, the

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interests outside the scope of the FFRDC contracts. Both RAND and Battelle conduct extensive R&D activities that have little or nothing to do with their FFRDC contract laboratories.

[4] See section 35.017 "Federally Funded Research and Development Centers," in the Federal Acquisition Regulation (FAR). https://www.acquisition.gov/?q=/browse/far/35

[5] "Majority of Federally Funded R&D Centers Report Declines in R&D Spending in FY 2013". National Science Foundation, April 16, 2015. http://www.nsf.gov/statistics/2015/nsf15319/

"management and operating (M&O) contract",[6] which, while available to other agencies, has only been used by the Department of Energy. This is a specific type of contract for the operation, maintenance, or support of a government-owned or -controlled facility. The M&O contract allows DOE to have a higher degree of control over contractor operations at its FFRDCs than other agencies do at their FFRDCs, and each laboratory reports to a DOE field office. DOE views this as appropriate because most of the DOE laboratories have very expensive government-owned equipment and/or work with nuclear materials and/or nuclear weapons. DOE has a high degree of oversight of the contractor's operations including:

- HR policies and benefits
- Equipment and other purchases
- Financial management
- Environmental, health and safety
- Security (physical, cyber security, personnel security)
- Management of nuclear materials and radioactive waste
- Records management
- Official foreign travel and others

DOE laboratories operating under an M&O contract have a higher degree of Federal involvement, and are more governmental in character, than other FFRDCs and UARCs. Other agencies that operate FFRDCs rely on the FFRDC managers' (or the parent companies') management systems to address operational issues, with much less direct Federal oversight.[7] DOE has been criticized because the high degree of regulations defeats many of the intended benefits of contractor operation. Instead of using best private sector management practices, they have many of the regulatory restrictions of government laboratories.

[6] See Federal Acquisition Regulation 17.6 "Management and Operating Contracts." https://www.acquisition.gov/?q=/browse/far/17

[7] National Academy of Public Administration. Positioning DOE's Labs for the Future: A Review of DOE's Management and Oversight of the National Laboratories. Washington: January 2013. http://www.napawash.org/wp-content/uploads/2013/01/DOE-FINAL-REPORT-1-2-13.pdf

UNIVERSITY AFFILIATED RESEARCH CENTERS

Since World War II, the Department of Defense has supported a number of major long-term relationships with universities that are not classified as FFRDCs. In 1996, DOD formalized some of these into UARCs, a new category of DOD research centers. UARCs are defined as college and university research organizations that receive sole source funds[8] exceeding, on average, $6 million annually; establish or maintain an essential engineering, research, or development capability; maintain a long-term, strategic relationship with DoD; and are designated as UARCs.[9] As with FFRDCs, UARCs have a strategic relationship with their sponsor that gives them knowledge of their sponsor's needs and access to their information. They are expected to be able to respond quickly to client needs, and are expected to independent and objective. UARCs differ from FFRDCs in that they:

- All have a university affiliation (as do some but not all FFRDCs)
- Have education as part of their mission

Current UARCs and Sponsors

Army

- University of California at Santa Barbara: Institute for Collaborative Biotechnologies
- University of Southern California: Institute for Creative Technologies
- Georgia Institute of Technology: Georgia Tech Research Institute
- Massachusetts Institute of Technology: Institute for Soldier Nanotechnologies
- University of Texas at Austin: Institute for Advanced Technology

Missile Defense Agency

- Utah State University: Space Dynamics Laboratory

Navy

- Johns Hopkins University: Applied Physics Laboratory
- Pennsylvania State University: Applied Research Laboratory
- University of Texas at Austin: Applied Research Laboratories
- University of Washington: Applied Physics Laboratory
- University of Hawaii at Manoa: Applied Research Laboratory

NASA

- University of California at Santa Cruz: UARC at Ames Research Center

National Security Agency

- University of Maryland, College Park: Center for Advanced Study of Language

Office of the Secretary of Defense

- Stevens Institute of Technology: Systems Engineering Research Center

U.S. Strategic Command (STRATCOM

- University of Nebraska: National Strategic Research Institute

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[8] Both FFRDCs and UARCs rely on an exemption from requirements for competition in contracting specifically for research organizations in the U.S. Code (the consolidation and codification by subject matter of the general and permanent laws of the United States) in 10 U.S.C. 2304(c)(3)(B).

[9] Engagement Guide Department of Defense University Affiliated Research Centers (UARCs) April 2013. http://www.acq.osd.mil/chieftechnologist/publications/docs/20130426_UARC_EngagementGuide.pdf

- Have somewhat more flexibility to compete for work than do FFRDCs

For the most part, there is very little difference between a UARC and a university-based FFRDC. As university organizations, they tend to be somewhat more research oriented, and less Federal in character than most FFRDCs. UARCs are mostly used by the Department of Defense, although NASA sponsors one UARC.

In addition to FFRDCs and UARCs, there are other federally-funded contractor operated laboratories. For example, the National Astronomy and Ionospheric Center, which includes the Arecibo Observatory in Puerto Rico, is a National Science Foundation facility managed by a contractor (formerly Cornell University, currently SRI International) under a cooperative agreement but is not considered an FFRDC.[10] Similarly, the Department of Energy operates three Tokamak fusion user facilities, each considered to be "user facilities" that are open to collaboration with scientists around the world. The largest is at General Atomics, a private company, in San Diego, and is not considered a GOCO laboratory or an FFRDC. A second is at the Princeton Plasma Physics Laboratory, a GOCO FFRDC located at Princeton University. The third is at MIT, but is not considered a GOCO lab or an FFRDC or a UARC. The three laboratories are functionally similar, but only the Princeton one is an FFRDC and a GOCO laboratory. The reasons for the different approaches are more historical than based on any particular rationale.

OTHER CONTRACT R&D ORGANIZATIONS

In addition to the above institutions, which have a long-term institutional relationship with an agency of the Federal government, there are also independent non-profit R&D organizations that work primarily for the Federal government, but on a project-by-project basis without any long-term institutional relationship. While these are not considered government laboratories, they may perform a large part of their work for government clients. Unlike UARCs and FFRDCs, these organizations do not have an exclusive relationship with a particular government agency, and do not have long-term commitments from federal agencies.

Examples include SRI International, Draper Laboratory, RTI International, Battelle Memorial Institute, and the Southwest Research Institute. All of these are independent contract R&D organizations, often working for DoD and other federal agencies. In addition, the U.S. has a large number of nonprofit biomedical research institutes that receive much of their funding from the federal government.

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[10] See www.naic.edu/general

Some of these independent nonprofit research organizations began as parts of universities. For example, Stanford University created the Stanford Research Institute in 1946 and quickly won contracts from government agencies. DoD liked this type of organization because it could draw upon top faculty members but also could perform interdisciplinary R&D and classified projects. They also had staff who were dedicated to research and focused on project management, so they tended to be better than university departments at meeting deadlines and other project commitments. SRI became an independent organization in 1970, during the Vietnam War and at a time when some students and faculty objected to universities conducting classified military research. There are some similar organizations – applied research units that often can do classified research but are not FFRDCs or UARCs -- that are still attached to universities.[11]

While these organizations do not have long-term institutional relationships with the Federal government, some may have fairly large and long-term contracts that provide a degree of financial stability. There are a variety of contracting mechanisms, known as “task order contracts” or “indefinite delivery/indefinite quantity (IDIQ)” contracts, that are multi-year in nature (typically 5 years) and enable the agency to assign the contractor to do a number of smaller tasks that are defined during the course of the project. There is typically an expected minimum, as well as a maximum amount of funding that can be provided in the contract, but within these limits the agency and the contractor can negotiate the scope, cost, and timing of individual tasks.

The use of these contracts provides, typically on a smaller scale, some of the same features as an FFRDC or UARC contract: they provide some stability to the contractor and enable the agency and the contractor to define projects without going through full and open competition for each task. (There is, however, usually strong competition to win the IDIQ contract in the first place). The main difference is that FFRDCs and UARCs are expected to continue indefinitely, while IDIQ contracts have no such expectation (although there are frequently follow-on contracts if the agency’s needs continue and the contractor’s performance has been good).

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[11] An example is the University of Dayton Research Institute, in Dayton Ohio. See www.udri.udayton.edu.

R&D CENTERS, HUBS, AND MANUFACTURING INSTITUTES

The institutions described above are primarily focused on serving government agency mission needs, such as defense, health, homeland security, energy, or science. Most of these organizational forms have been in place for at least 50 years. (The UARC designation is more recent, but many of the UARC labs have a longer history.)

Beginning in the 1980s, federal officials began to support new types of research organizations that deliberately linked universities with companies and in some cases linked together groups of universities, companies, and federal laboratories. These organizations are various types of R&D centers, "hubs," and institutes, and they usually are operated by individual universities, consortia of universities, or other nonprofit consortia. These are less focused on meeting government mission needs, and more focused on generating knowledge that would provide long-term economic and social benefits.

These centers, hubs, and manufacturing institutes differ significantly from the organizations described above in that:

- The government does not own or control the research facilities (although government laboratories sometimes participate in the DOE hubs).
- Federal funding usually lasts for only a limited number of years, after which the organizations are expected to find other support or change directions.
- They usually perform only unclassified research, and are designed to transfer and commercialize knowledge rather than control information.
- They have educational components (recognizing that graduating students are an important way to transfer knowledge).
- They are expected to obtain multiple sources of funding – from industry, state government, and other sources (reflecting a belief that the research will be more relevant and useful if stakeholders share in its ownership and direction).

There are a wide number of different types of centers and institutes with these characteristics. Below we discuss three examples of this type of R&D organization:

- NSF's Engineering Research Centers (ERC) Program
- DOE Energy Innovation Hubs Program
- Manufacturing Institutes, supported by DOE and DOD

NSF Engineering Research Centers.[12] NSF first funded ERCs in the mid-1980s, and the program continues to today. Its purpose was – and remains – to connect university engineering research and education more closely to companies. Before ERCs, NSF had funded some multidisciplinary laboratories at universities, but the ERCs had certain innovative features: they were larger, they often focused on new multidisciplinary areas of engineering (for example, bioengineering), they had close connections with industry, the NSF required cost-sharing (often through industry contributions), and the centers emphasized education as well as research. All ERCs were, and remain, based at universities. NSF provides funding for each center for up to 10 years.

Some ERCs have been more successful than others in attracting and keeping corporate support and in transferring new technologies to the private sector. However, because centers are required to have close ties with industry, ERCs do often conduct research that industry cares about and train students with skills industry wants. Since ERCs are based at universities and having limited funding, they can conduct valuable basic research and applied research but are not designed to produce operational technologies. Also, ERCs do not conduct classified research, so the government needs to turn other types of research organizations to carry out secret projects.[13]

The Engineering Research Centers are small compared to most of the federal laboratories. In 2012, annual funding for each Center is typically in the range of $3.5 to $10.0 million, with NSF's contribution ranging from $2.7 million (for centers in their phase-down period prior to graduation from NSF support) to $3.25 to $4.2 million per year for ongoing centers.[14] Since the program's inception, over 60 centers have been funded, and about 20 are currently receiving funding. Many of the others are continuing as centers even after their NSF center funding has run out.

DOE ENERGY INNOVATION HUBS

The Energy Innovation Hubs, first established in 2010, are "integrated research centers that combine basic and applied research with engineering to accelerate scientific discovery that

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[12] The ERC program is the most prominent but by no means the only such center program supported by NSF. Other programs include the Industry-University Cooperative Research Centers, the Materials Research Centers, and the Science and Technology Centers.

[13] For additional information on the ERC program, please see these two websites: http://www.nsf.gov/div/index.jsp?div=eec and http://erc-assoc.org/.

[14] Engineering Research Centers: Linking Discovery to Innovation. http://erc-assoc.org/sites/default/files/ERC%20Overview%20Fact%20Sheet_2012-final.pdf

addresses critical energy issues."[15] The Hubs are intended to advance promising areas of energy science and technology from their early stages of research to the point that the risk level will be low enough for industry to commercialize the technologies. Each is focused on a particular energy challenge that had been resistant to solution by conventional R&D management structures. The defining characteristics of the Hubs were to be:[16]

- A lead institution with strong scientific leadership;
- A central location;
- If geographically distributed, state-of-the-art tele-presence technology to enable long distance collaboration; and
- A strong organization and management plan to effect goals.

There are currently four hubs:

- The Consortium for Advanced Simulation of Light-Water Reactors
- The Joint Center for Artificial Photosynthesis
- The Joint Center for Energy Storage Research (battery technology)
- The Critical Materials Institute

The hubs are complex organizations; each has several members. For example, the Joint Center for Artificial Photosynthesis is led by the California Institute of Technology in partnership with Lawrence Berkeley National Laboratory, the SLAC National Accelerator Laboratory at Stanford, the University of California at Irvine, and the University of California at San Diego. The hubs deliberately include both universities and DOE national laboratories. The research is unclassified. Initial funding for each hub is for five years, with the possibility of an additional five years. For example, in April 2015 the Joint Center for Artificial Photosynthesis received a DOE award for its second five years; the award is for up to $75 million dollars for these next five years.[17] The DOE hubs are new, so it is too early to judge their effectiveness. The hubs (along with three other new R&D mechanisms, including ARPA-E, Bioenergy Research Centers, and Energy Frontier Research Centers) were assessed by a Task Force of the Secretary of Energy Advisory Board, which was generally supportive of the hubs model, but made a number of recommendations for strengthening the program.[18]

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[15] http://energy.gov/science-innovation/innovation/hubs

[16] Secretary of Energy Advisory Board. Task Force Report to Support the Evaluation of New Funding Constructs for Energy R&D in the DOE. March 28, 2014. http://www.energy.gov/seab/downloads/seab-hubs-report

[17] These details on the Joint Center for Artificial Photosynthesis are from: http://science.energy.gov/bes/research/doe-energy-innovation-hubs/.

[18] Secretary of Energy Advisory Board. Task Force Report to Support the Evaluation of New Funding Constructs for

MANUFACTURING INSTITUTES

The Obama Administration has also created the National Network for Manufacturing Innovation (NNMI), which consists of several Institutes for Manufacturing Innovation (IMIs). These are joint government-university-industry centers that create new technologies, skills, processes, and products for both large and small companies in specific industrial sectors. To some extent, the institutes are based on Germany's Fraunhofer Institutes, which provide technology, training, and contract R&D services for German companies. Currently, the U.S. Government is contributing to nine IMIs, in fields such as additive manufacturing, semiconductors, hybrid electronics, photonics, clean energy, and fibers and textiles.[19]

Most of the federal money for these institutes has come from the Defense Department and the Energy Department. President Obama has asked Congress to provide additional funding for up to 45 institutes, but so far Congress has not provided that additional money.

Each institute receives a combination of federal and non-federal funds. For example, the Manufacturing Innovation Institute for Integrated Photonics has a total 5-year budget of over $610 million -- $110 million from the Department of Defense and more than $500 million in non-federal contributions from companies, state governments, and universities. This institute is organizationally complex: it is a consortium of 124 companies, nonprofits, and universities, led by the Research Foundation for the State University of New York.[20] The manufacturing institutes are also new, so no one knows yet whether they will be successful. Each has many participants, which may be both a problem (e.g., they may be hard to manage) and an asset (e.g., they have many contributors and many potential beneficiaries).

DISCUSSION OF STRENGTHS AND WEAKNESSES OF INSTITUTIONAL MECHANISMS

Table 1 provides a brief and simplified overview of the characteristics of the different mechanisms. This section then discusses in more detail the strengths, weaknesses and other characteristics of the various mechanisms with respect to:

- Establishing and maintaining high quality facilities and equipment
- Hiring technical talent
- Management practices

Energy R&D in the DOE. March 28, 2014. http://www.energy.gov/seab/downloads/seab-hubs-report

[19] http://manufacturing.gov/institutes.html

[20] https://www.whitehouse.gov/the-press-office/2015/07/27/fact-sheet-vice-president-biden-announces-new-integrated-photonics

- Types and quality of R&D
- Technology transfer and commercialization
- Assessing performance

TABLE 1. TYPES OF FEDERALLY-FUNDED LABORATORIES AND OTHER INSTITUTIONS AND A SUMMARY OF THEIR CHARACTERISTICS

CHARACTERISTIC	GOGOs	GOCOs, FFRDCs, and UARCs	NONPROFIT INDEPENDENT R&D ORGANIZATIONS	CENTERS/HUBS/ INSTITUTES
Examples	NIST, NRL, AFRL, NASA field centers (except JPL), NIH intramural	FFRDC labs (most DOE labs, JPL, MIT Lincoln Laboratory, NSF 's atmospheric and astronomy centers, Project AirForce at RAND) and DoD UARCs	SRI International, Battelle, Draper Lab, Southwest Research Institute, various nonprofit biomedical research institutes	NSF ERCs, DOE Energy Innovation Hubs, National Network of Manufacturing Innovation institutes
Who owns facilities	Government owns or leases the facilities	Some are government owned or leased. Some are owned by the contractors.	The nonprofit R&D organizations own the facilities	Universities, companies, or nonprofits usually own facilities
Managers and main technical staff	Government employees	Private contractors, overseen by federal agencies	Contractor employees	Contractor employees
Hiring and management flexibility	Limited ability to change direction or staff; hiring hampered by low government salaries and requirements for U.S. citizenship	Considerable flexibility to hire staff and manage them, but under federal supervision	Generally high flexibility	Generally high flexibility

Long-term federal commitment?	Yes	Yes	No formal long-term commitment but often long-term relationships	Usually not; federal awards limited to fixed periods of time
R&D contracting mechanisms	GOGO labs subject to annual appropriations and usually can accept funds from other federal agencies	Agencies can quickly award sole-source contracts to their FFRDCs/UARCs. FFRDCs cannot participate in open competitions for additional projects.	Generally compete on project-by-project basis, but may often have longer-term IDIQ contracts.	Often operated under an agreement that provides annual funding for 5 years.
Type and quality of R&D	Can perform both classified and unclassified R&D and technology development as well as research. Often used for R&D program management.	Both classified and unclassified R&D. Particularly good at complex multi-disciplinary technology projects	Both classified and unclassified R&D. Can develop technology as well as conduct basic research.	Unclassified R&D. University centers and hubs focus on research rather than development of operational technology,
Assistance to the private sector	CRADAs legally allowed, but number varies greatly from lab to lab. Cannot assert copyright protection over works created at GOCOs including software.	DOE and DoD GOCOs can do CRADAs and work for others but are often limited in how much they can work with companies. Can assert copyrights.	Under Bayh-Dole, nonprofits may keep patent rights and license them. Some nonprofits spin out companies. Can assert copyrights.	Under Bayh-Dole Act, universities, other nonprofits, and small firms may keep patent rights and license them. Can assert copyrights.

FACILITIES AND EQUIPMENT[21]

The U.S. Government generally prefers that very expensive research facilities (accelerators, nuclear reactors, light sources, radio telescopes) be in government-owned facilities (GOGO or GOCO laboratories) where the government has a high degree of control over its investment. While some very expensive facilities are in GOGO laboratories, the U.S. generally prefers GOCOs because of a better ability to hire and retain the highly skilled technical staff. It is much harder for independent research laboratories to be the location for very expensive equipment, because it is difficult to establish and maintain such facilities using relatively short-term contracts, and because there are questions about what to do with the facilities when the contract ends. If, however, the goal is to use Federal funds (often with state and industry co-funding) to support R&D facilities that are available to industry (rather than to serve government needs), it may be appropriate to put expensive equipment in centers, hubs, or manufacturing institutes.

HIRING TECHNICAL TALENT

A main reason for establishing contractor operation of laboratories was to make it easier to hire and retain top technical talent, including senior program and project managers. Contractor operated laboratories are generally not limited by government personnel rules, civil servant salary ranges, and limits on the number of employees. Many top scientists and engineers prefer to work for academic or non-profit institutions rather than government agencies.

There are, however, many excellent scientists and engineers in GOGO laboratories, including Nobel Prize winning scientists at NIST and NIH. Some of these laboratories have excellent reputations and are viewed as good places to work. They are attractive to some scientists because of the stability of funding and the highly challenging nature of the work.

Non-governmental organizations have somewhat more flexibility in hiring non-U.S. citizens. In general, only U.S. citizens can be hired to regular civil service jobs, whereas most contractors can hire non-U.S. citizens (with appropriate visas). However, depending on the nature of the work, non-U.S. citizens may not be allowed to participate in certain contracts at contractor

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[21] A substantial number of the most expensive facilities housed in GOGOs and GOCOs are made available for temporary use by non-governmental organizations, including companies, under “User Facility” arrangements. These are especially common at DOE National Laboratories.

operated-laboratories.[22] There are generally no limits on hiring non-U.S. citizens (with appropriate visas) for open work of the kind that is conducted in university based centers or hubs. Even for laboratories that have restrictions on the use of non-U.S. citizens, there are often international postdocs and visiting scientists, both at Federal laboratories and FFRDCs and UARCs. A 2013 survey of post-docs at FFRDCs found that of 2,613 postdocs, 1150 were U.S. citizens or permanent residents ("green card" holders) and 1,463 were temporary visa holders. Clearly there are ample opportunities to attract international talent to FFRDCs, at least on a temporary basis. [23]

MANAGEMENT PRACTICES

A main reason to use contractor management of laboratories has been to bring private sector management practices and experience to the laboratories, and to free the laboratories from some of the government regulations that GOGOs must work under. As discussed earlier, this goal has partially been undermined, especially in the case of the DOE operated GOCO FFRDCs, by Federal oversight that has made contractor operations overly bureaucratic and inefficient.[24]

It is generally perceived that non-DOE FFRDCs and UARCs and independent laboratories are less regulated and use more private sector management practices than the DOE FFRDCs. Centers and hubs, which are often operated under cooperative agreements, are perceived to have the most freedom of actions.

A benefit of GOCO laboratories is that it is possible, at least in theory, to change the managing contractor if it is not performing well. This is most feasible for government-owned facilities that not are closely integrated with the contractor's own facilities (such as the geographically remote national laboratories like Los Alamos, Sandia, Brookhaven, and Oak Ridge National Laboratories, among others). For laboratories that are more closely integrated with the contractor, such as those on university campuses (e.g., Lawrence Berkeley National Laboratory or the Princeton Plasma Physics Laboratory) it is more difficult to change the managing contractor. The Department of Energy has held competitions for the management contracts for 14 of 16 of its GOCO laboratories, and in several cases it has changed the management

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[22] The country of origin of the employee also matters in whether non-citizens may be hired or assigned to work on classified projects.

[23] Kang, Kelly. "Postdocs at Federally Funded R&D Centers: Fall 2013. Detailed Statistical Tables | NSF 15-312. February 2015. http://nsf.gov/statistics/2015/nsf15312/pdf/nsf15312.pdf

[24] For example, see the report of the Secretary of Energy Advisory Board on "Alternative Futures for the Department of Energy National Laboratories". http://www2.lbl.gov/LBL-PID/Galvin-Report/Galvin-Report.html

team. The benefits of these changes have often been lower than had been expected. DOE concluded that its "experiences in competing its M&O contracts suggest that the typical benefits expected of contract competition are not always realized in these types of competitions as they did not necessarily result in either: 1) significant competition or a substantively new contractor; 2) cost savings for the government; or 3) substantially improved contractor performance." [25] However, the ability of the government to potentially change the management of a laboratory may help to keep the existing management from becoming too complacent.

For contractor-owned FFRDC or UARCs, it is generally difficult to change the management contractor without severely disrupting the organization.[26] In these cases, if an organization is performing poorly, the government may pressure the contractor to make management changes, and if this is not successful, the government may seek to reduce the lab's funding and fund other organizations instead.

Independent research organizations generally compete for work on a project by project basis, and thus they need to demonstrate management competence on an ongoing basis. Centers, Hubs, and Manufacturing Institutes are also generally on medium term contracts (often 5 years with a possibility of renewal) and thus will not survive if they are poorly managed.

TYPE AND QUALITY OF R&D

All of the types of R&D performing institutions are a capable of performing high quality R&D. GOGO labs are often viewed as having the most difficulty in attracting top researchers but several GOGO laboratories have won Nobel Prizes. Nevertheless each of the types of organizations have niches where they have comparative advantages:

- GOGO labs excel in managing large technical systems. Because the employees are Federal employees, they can perform "inherently governmental function" such as making decision about program directions and funding that contractors are not allowed

[25] See DOE's policy on competing management contracts. http://science.energy.gov/~/media/lp/pdf/management-and-operating-contracts/DOE_Policy_Extension_or_Competition_of_Contracts_for_National_Labs_2009-12-22.pdf

[26] There has been at least one case of changing the management of a non-GOCO FFRDC: the management of the Science and Technology Policy Institute (STPI) was changed from the Rand Corporation to the Institute for Defense Analysis. This involved replacing all of the staff and management of STPI.

to do.[27] Many Federal laboratories have become primarily places that manage large technological projects performed largely by contractors, rather than places that primarily perform R&D. For examples, many of NASA's Centers, as well as the Air Force Research Laboratory, are largely program management centers. Federal labs also tend to be more stable in their funding and staffing, and can pursue research that requires a very stable environment.

- GOCO FFRDCs (such as the DOE national laboratories) tend to excel at managing very large scientific facilities (light sources, accelerators) and performing high security work.
- Non-GOCO FFRDCs & UARCs excel at confidential, client-oriented R&D and analysis.
- Independent R&D organizations excel at mid-sized client-oriented applied R&D projects.
- Centers, hubs, and manufacturing institutes excel at interdisciplinary research that is connected to company needs and that trains students.

TECHNOLOGY TRANSFER AND COMMERCIALIZATION

For GOGOs, FFRDCs, and UARCs, technology transfer to companies is allowed and encouraged, but the main organizational focus is on government missions; interacting with commercial industry is at best a secondary goal. Many engage in cooperative R&D agreements (CRADAs) with industry, and there have been some spinoffs and licensed technologies, but the amount of technology commercialization per research dollar is low compared to that from other institutional mechanisms. GOGOs can receive patents for their federal employees' inventions but are not allowed to assert copyright protection over works, including software, created by their federal employees, under the general principle that all such works are the property of the nation as a whole. This limits their ability to work with companies to develop new software.

Independent R&D organizations, such as SRI International and Battelle, are allowed to retain title to intellectual property resulting from government-sponsored contracts, and the organizations can gain substantial financial benefits from commercializing technology. Centers, Hubs, and Manufacturing Institutes are intended by design to work on problems of importance to industry. Much of the work is more "upstream," – that is, more basic and exploratory – and results in new knowledge rather than technologies that are ready for commercialization. However, they, too, can claim both patent ownership and copyrights in work created by their staffs. Often, a condition of receiving government funds is that such collaborative research institutions put in place a formal internal policy and procedure for managing and sharing the benefits from such intellectual property among their members.

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[27] See policy letter on inherently governmental functions. http://www.gpo.gov/fdsys/pkg/FR-2011-09-12/pdf/2011-23165.pdf

ASSESSING PERFORMANCE

The different types of laboratories use different types of mechanisms to assess their performance. It is useful to distinguish between project performance (how well projects are executed), programmatic performance (how well the laboratories are serving the needs of the client), and operational performance (how well the laboratories follow safety, security, financial, and other rules).

Project performance assessment is similar throughout the organizations: projects have plans with milestones, deadlines, and budgets, and project performance is evaluated by how well they achieve their plan. Clients are also asked for feedback on how useful the projects were. For programmatic performance, GOGOs and FFRDCs and UARCs typically use advisory committee processes. These include reviews by the National Academies[28], visiting committees, advisory board in specific technical areas, and oversight boards composed of the laboratories stakeholders. The National Academy of Public Administration is sometimes used for management reviews.[29] Operational performance in the case of DOE laboratories is often assessed by DOE onsite personnel, who review performance in detail in various areas (safety, security, record keeping, accounting, etc.) There is also oversight by the Defense Nuclear Facilities Safety Board, as well as by the DOE Inspector General. The results of DOE evaluations (in various categories, including both mission performance and operations) affect the award fee on the contract as well as the contractor's eligibility for a contract extension. In the case of non-DOE FFRDCs and UARCs, the agency generally assesses the contractor's overall management system.

For independent research organizations, which operate mostly on short-term projects, most performance assessment comes when applying for new contracts. A standard part of many proposals for new work is an assessment of past performance that is solicited from previous clients.

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[28] See: Heaton, G.R., Jr., C.T. Hill and P.Windham, The Roles of the U.S. National Academies in Influencing Federal S&T Initiatives, Report to NEDO by Technology Policy International, December 2014.

[29] National Academy of Public Administration. Positioning DOE's Labs for the Future: A Review of DOE's Management and Oversight of the National Laboratories. Washington: January 2013. http://www.napawash.org/wp-content/uploads/2013/01/DOE-FINAL-REPORT-1-2-13.pdf

For DOE hubs and manufacturing institutes, assessment processes are still being defined. They will certainly include (and have already included) advisory committee reviews,[30] and they will also be evaluated in the long run on their impact on industry.

BENEFITS FOR THE GOVERNMENT AND THE CONTRACTING ORGANIZATIONS OF DIFFERENT TYPES OF ARRANGEMENTS

The benefits for the government in using the different kinds of arrangement include the following:

- For all kinds of contracting arrangements, the government benefits by getting work done without using any federal personnel slots, or without taking on employment and hiring burdens.
- For FFRDC and UARCs, the government benefits by having a long-term source of specialized research and technical advice, dedicated to the government, with rules that allow confidential discussions and freedom from conflicts of interest.
- For independent research organizations, the government gets work done on a competitive basis with no long-term financial commitment.
- For centers, hubs, and manufacturing institutes, the government is providing support to research and technology development that is expected to benefit the economy, through the generation of new knowledge and talent.

From the contractor's point of view, all of these types of contracts are of potential interest, and contractors can be found to bid on any of the types of contracts. The incentives are primarily financial, but also include the prestige and stability that come with major Federal contracts. Winning an FFRDC, a UARC or a major hub can provide a boost to a university's or other organization's research reputation and provide a degree of long-term financial stability.

There are, however, several things potential contractor must consider before seeking such contracts. One is the cost and risk of bidding – a formal proposal to the government to win a major contract (e.g. managing a national laboratory or an FFRDC) may cost from several hundreds of thousands to several million dollars in time and opportunity costs. Contractors do a cost/benefit analysis when deciding to bid on such a major contract, looking at the cost of preparing a proposal, the probability of winning, and the expected benefits of winning. Based on these considerations, the Department of Energy has sometimes found that relatively few

[30] Secretary of Energy Advisory Board. Task Force Report to Support the Evaluation of New Funding Constructs for Energy R&D in the DOE. March 28, 2014. http://www.energy.gov/seab/downloads/seab-hubs-report

contractors are willing to bid on managing national laboratories, largely because the cost of preparing a proposal is high, the probability of winning may be viewed as low if there is already an incumbent, and the potential financial benefits are not sufficient to outweigh the cost and risk of failure.

Another issue, especially for universities considering whether to bid for FFRDCs or UARCs, is whether a government-dedicated laboratory fits with the mission of the university. In particular, there are concerns about the requirements for secrecy/confidentiality that may come with FFRDCs and UARCs, and there may be concern about whether the FFRDC staff would fit with the teaching faculty of the university. Faculty committees at the University of California voted against the university's continued management of the Los Alamos and Lawrence Livermore National Laboratories because they believed that operation of these nuclear weapons laboratories was not consistent with the mission of the university.[31] Some university faculty and students have also been opposed to large Department of Defense laboratories on campuses.

For centers, hubs, and manufacturing institutes, another issue is that there are typically cost-sharing requirements, so the bidding organization often has to organize state government, industrial, or philanthropic funding to contribute to the projects. This may take substantial effort, and universities may have limited resources to raise these funds, as well as competing demands for limited state or philanthropic funds.

CONCLUSIONS

The United States government uses a wide variety of institutional mechanisms to perform R&D in support of government missions as well as to support the general national economy. In general, the trend in recent years has been toward use of more private sector ownership and management, and more networked forms of laboratories. There have been few new GOGO laboratories or even GOCO laboratories established in recent years because:

- Existing government labs and a diverse range of other research organizations can handle most of the needed functions;
- There has been an increasing preference for using contractor-operated organizations for R&D functions; and

[31] See for example: http://articles.latimes.com/1990-09-14/news/mn-184_1_uc-faculty

- There is recognition of the value of involving universities and industry in R&D to facilitate human capital development and technology transfer.

In recent years, when new government needs have arisen, (such as for homeland security or cybersecurity) the U.S. has tended to create new FFRDCs or UARCs rather than new government-owned laboratories.

The U.S. Government also has moved away from labs focused on government missions to new organizational forms intended to facilitate interdisciplinary work and the transfer of knowledge to industry and spinoff companies. Most of these institutions are both networked and transient by design – they are intended to foster industry-university-government collaboration in a key technology area and then over time either transition to private sector support or change form as the technology changes. Some of these mechanisms – the energy hubs and manufacturing institutes – are quite new and their effectiveness remains to be proved.