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April 2024

FEDERAL RESEARCH

Key Practices for Scientific Program Managers

GAO-24-106297

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GAO Highlights

Highlights of GAO-24-106297, a report to the Committee on Science, Space, and Technology, House of Representatives

Why GAO Did This Study

The federal government invests in basic and applied scientific research to drive innovation, promote economic competitiveness, and enhance national security. The National Science Foundation estimates that 32 federal agencies funded over $85 billion in basic and applied research in fiscal year 2021.

Scientific program managers at federal agencies that sponsor basic and applied research play a critical role in guiding and shaping the research funded by their agencies.

In this report, GAO describes key practices that federal program managers use to manage their research.

GAO held 14 group discussions with 79 program managers from seven selected agencies that funded over 90 percent of basic and applied research obligations in fiscal year 2021. GAO asked the program managers to describe the practices they use when managing projects in their basic and applied research portfolios. GAO conducted qualitative analysis to identify common themes and distilled them into 10 key practices. These key practices were cited by multiple program managers or agencies and could be used by program managers across the federal government when managing projects in their basic and applied research portfolios.

GAO also conducted a literature review to help corroborate the key practices. GAO sought and incorporated feedback on these practices from the selected agencies as well as experts identified by the National Academies of Sciences, Engineering, and Medicine.

View GAO-24-106297. For more information, contact Candice N. Wright at (202) 512-6888 or wrightc@gao.gov.

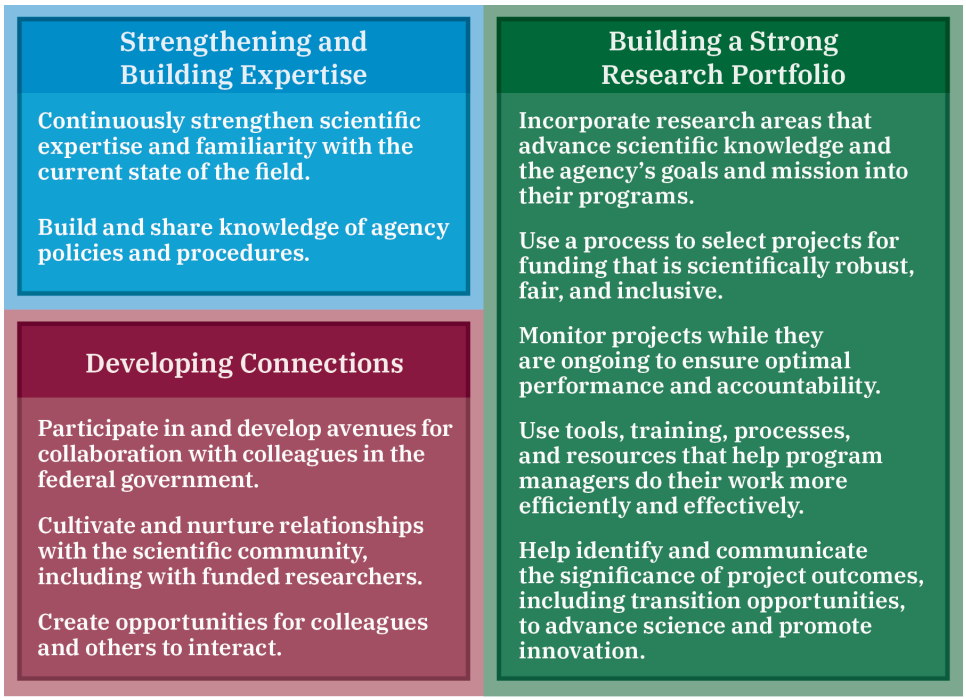
What GAO Found

To oversee basic and applied research at federal agencies, scientific program managers are typically responsible for managing award selection, monitoring ongoing awards, and coordinating with awardees and the research community. Program managers GAO interviewed from selected agencies identified key practices they used to carry out these responsibilities. They said these practices helped advance their agencies' goals, further science, and avoid unnecessary duplication. Further, the practices may help program managers, agencies, and others assess and improve management of basic and applied research.

As outlined in the figure below, the key practices fall into three areas.

- Strengthening and building expertise—Practices that help program managers maintain scientific and management expertise.
- Developing connections—Practices that help program managers enhance collaboration with the scientific community and the public, as well as within their own agencies and in other agencies.
- Building a strong research portfolio—Practices that help program managers advance their agencies' research mission and scientific knowledge in general, while ensuring their own accountability and that of federally funded researchers.

Key Practices for Federal Program Managers to Select, Coordinate, and Monitor Scientific Research



Sources: GAO analysis of discussions with scientific program managers. | GAO-24-106297

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Abbreviations

ARPA-E	Advanced Research Projects Agency-Energy
CFR	Code of Federal Regulations
DARPA	Defense Advanced Research Projects Agency
DEVCOM	U.S. Army Combat Capabilities Development Command
DOD	Department of Defense
DOE	Department of Energy
EPA	Environmental Protection Agency
FAR	Federal Acquisition Regulation
FFRDC	Federally Funded Research and Development Centers
HHS	Department of Health and Human Services
NASA	National Aeronautics and Space Administration
NIH	National Institutes of Health
NNSA	National Nuclear Security Administration
NSF	National Science Foundation
OMB	Office of Management and Budget
OPM	Office of Personnel Management
ORD	Office of Research and Development
PFAS	per- and polyfluoroalkyl substances
RePORTER	Research Portfolio Online Reporting Tool (Expenditures and Results)
R&D	research and development
RPPR	Research Performance Progress Report
SRO	scientific review officer
VA	Department of Veterans Affairs

U.S. GOVERNMENT ACCOUNTABILITY OFFICE
441 G St. N.W.
Washington, DC 20548

April 8, 2024

The Honorable Frank D. Lucas
Chairman
The Honorable Zoe Lofgren
Ranking Member
Committee on Science, Space, and Technology
House of Representatives

Federal investments in basic and applied scientific research spur innovation and promote the economic competitiveness, prosperity, and security of the nation. The National Science Foundation (NSF) estimates that 32 federal agencies funded over $85 billion in basic and applied research in fiscal year (FY) 2021.[1] Past investments in basic and applied research have led to major scientific breakthroughs. Examples include the Department of Energy's (DOE) mapping of the human genome, Department of Defense's (DOD) research on stealth technologies, Department of Health and Human Services' (HHS) development of magnetic resonance imaging technologies, and National Science Foundation's (NSF) capture of the first image of a black hole. As policymakers consider how to prioritize spending in a constrained and uncertain budgetary environment, conducting federal research and development (R&D) in an effective and coordinated manner becomes increasingly important.

Scientific program managers at federal agencies that sponsor basic and applied research play a key role in guiding and shaping the research funded by their agencies. Their position titles vary from agency to agency, and include "program manager," "program director," "program officer," and others. However, their duties are similar throughout the federal government in that they direct the process of selecting research projects for funding; monitor and evaluate the technical and scientific aspects of

[1]National Science Foundation, National Center for Science and Engineering Statistics, *Survey of Federal Funds for Research and Development: Fiscal Years 2020-2021*, NSF 22-323 (Alexandria, VA: 2022). As defined by the Office of Management and Budget (OMB), basic research is "experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundations of phenomena and observable facts. Basic research may include activities with broad or general applications in mind… but should exclude research directed towards a specific application or requirement." Applied research is "original investigation undertaken to acquire new knowledge, but directed primarily towards a specific, practical aim or objective." OMB, *OMB Circular No. A-11, Preparation, Submission, and Execution of the Budget*, § 84.2(c), at 4 (Aug. 2023).

ongoing awards; and coordinate with funded researchers, other federal officials, and the broader research community to seek synergies and avoid unnecessary duplication of research efforts.

Program managers play a vital role in the success of federal R&D. This report identifies key practices that program managers use in selecting, monitoring, and coordinating research for their agencies. As such, it may serve as a resource to help program managers, agencies, and others to understand, assess, and improve the management of basic and applied research.

We prepared this report under the authority of the Comptroller General to investigate, evaluate, and audit federal programs and activities. This report identifies and examines key practices federal scientific program managers report using to effectively implement processes for selecting, coordinating, and monitoring basic and applied research. This report builds on past GAO work and findings to improve management of R&D, such as those related to the evaluation of an agency's R&D portfolio performance and avoiding overlap and duplication of research conducted by other agencies.[2] While most GAO work has generally focused on research at individual agencies or on specific research topics, this report examines the federal R&D enterprise as a whole, following our December 2022 report on federal R&D funding.[3]

We define a "key practice" as an activity that federal program managers may engage in and that may or may not be included in their documented duties, but plays a role in the effective selection, coordination, or monitoring of research such that agencies' research goals may not be achievable without it. Key practices are also those that have broad applicability across the federal research agencies, as the exact roles and responsibilities of program managers vary from agency to agency.

To identify key practices used by scientific program managers, we conducted 14 group discussions with 79 program managers from seven selected agencies that fund basic and applied research. We selected the

[2]See, for example, GAO, *Nuclear Security Enterprise: NNSA Could Enhance Its Evaluation of Manufacturing-Related R&D Performance,* GAO-22-104506 (Washington, D.C.: May 20, 2022), and GAO, *Advanced Research Projects Agency-Energy: Agency Has Practices for Avoiding Duplication and Involving Stakeholders in the Development of Research Programs,* GAO-22-104775 (Washington, D.C.: Feb. 3, 2022).

[3]GAO, *Federal Research and Development: Funding Has Grown since 2012 and Is Concentrated within a Few Agencies,* GAO-23-105396 (Washington D.C.: Dec. 15, 2022).

five agencies that accounted for almost 90 percent of basic and applied research obligations in FY 2021: DOD, DOE, HHS, the National Aeronautics and Space Administration (NASA), and NSF.[4] We also selected the Department of Veterans Affairs (VA) because it funds a substantial amount of its research through competitive intramural awards, and the Environmental Protection Agency (EPA) because it funds both intramural and extramural research and is a small agency by comparison with our other selected agencies.[5] For HHS, we focused on the National Institutes of Health (NIH), because among HHS's operating divisions, NIH reported obligating over 95 percent of HHS's total basic and applied research obligations in FY 2021.[6]

To identify program managers for participation in the group discussions, we randomly selected individuals from both agency-provided lists and publicly available sources. During our group discussions, we asked the program managers to describe the key practices, as defined above, that they use in their work. We then used the qualitative analysis software NVivo to identify common themes cited by multiple program managers or agencies, and distilled those themes into 10 key practices that could be used by program managers across the federal government when managing projects in their basic and applied research portfolios.

We also conducted a literature review to further support the practices that we identified and sought and incorporated feedback on these practices from the agencies. To identify relevant literature, we searched databases such as ProQuest, Scopus, and EBSCO for results from sources such as scholarly and peer reviewed journals, trade magazines, and association

[4]The most recent research obligations data available at the start of this study were preliminary estimates for FY 2021. NSF, National Center for Science and Engineering Statistics, *Survey of Federal Funds for Research and Development: Fiscal Years 2020–21*. NSF 22-323 (Alexandria, VA: 2022). NSF referred to these FY 2021 data as 'preliminary' in survey documentation because these data were updated in the subsequent volume of the survey. We refer to FY 2021 data as 'estimates' throughout this report.

[5]Intramural research is research performed by scientists employed by a federal agency. Extramural research is performed by scientists employed by a non-federal institution, such as a university or private business, under a federal financial award or contract.

[6]An obligation is a definite commitment that creates a legal, government responsibility for payment of goods and services ordered or received, or a legal duty on the part of the United States that could mature into a legal liability by virtue of actions on the part of the other party beyond the control of the United States. An agency incurs an obligation, for example, when it places an order, signs a contract, awards a grant, purchases a service, or takes other actions that require the government to make payments to the public or from one government account to another. GAO, *A Glossary of Terms Used in the Federal Budget Process*, GAO-05-734SP (Washington, D.C.: Sept. 2005).

and think tank publications from the past 10 years. We also asked internal and external experts and stakeholders we interviewed if they could recommend any relevant sources. We found no sources that directly addressed the topic of this report. We sought and incorporated feedback on our key practices from the selected agencies by providing them with a draft of the key practices that we identified using the process described above. We also sought and incorporated feedback from experts identified by the National Academies of Sciences, Engineering, and Medicine.

We conducted this performance audit from October 2022 to April 2024 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Background

Funding for Scientific Research

Federally funded research may be performed by scientists employed by federal agencies (intramural research) or by scientists employed by businesses, higher education institutions, or non-profit organizations (extramural research).[7] Extramural research is usually awarded in one of two ways: either through contracting or as federal financial assistance.

Contracting. The federal government uses contracting to purchase goods or services that benefit it directly. Contracting is generally governed under the Federal Acquisition Regulation (FAR), as well as specific agency supplements to the FAR, and gives the government a substantial amount of control over the performance of the work carried out by the contractor. For example, the federal government typically sets the scope of work and establishes both technical and cost criteria for contracts. Contractors must adhere to specified schedules for the delivery of goods or services and if they fail to do so they may be considered in default of the contract.

Financial assistance. The federal government generally uses financial assistance instead of contracting when funds are intended to support a public purpose rather than to be used directly by the federal government.

[7]Some federally funded research is performed at federally funded research and development centers (FFRDC), which are owned by the federal government and operated by partners in the private, higher education, or non-profit sectors.

Regulations for these types of federal awards, including grants and cooperative agreements, can be found at 2 C.F.R. Part 200. The federal government can provide financial assistance through a variety of financial instruments, but most commonly uses either grants or cooperative agreements to support scientific research.[8]

Financial assistance entails less involvement than contracting between the federal government and the funding recipient. For example, with grants, the recipient sets the scope of work, and is generally not required to meet milestones or produce deliverables beyond the performance of the work for which the grant was awarded. Cooperative agreements allow for substantial involvement by the federal government. For example, a cooperative agreement may specify that agency scientists will work alongside members of the extramural research team. Like grants, though, cooperative agreements can allow the funding recipient to set the scope of work and do not necessarily require the achievement of specific milestones and deliverables.

Scientific research, particularly at the basic and applied levels, is often unpredictable. For example, determining at the outset whether a research project will have a practical impact can be difficult. Further, even projects that produce negative results may have value in revealing that a given approach will not work or in identifying promising new research directions.[9] For those reasons, contracting, with its focus on milestones

[8]Both grants and cooperative agreements involve a federal obligatory official signing a funding instrument between the federal government and recipient of the funds, but these contracts are different from contracts governed under the FAR. In addition, Congress has authorized certain agencies, including DOD, DOE, HHS, NASA, and NSF to enter into agreements under a separate authority, referred to as "other transaction authority." This authority allows an agency to enter into agreements "other than" standard government contracts or other traditional mechanisms. Agreements under this authority are generally not subject to federal laws and regulations applicable to federal contracts or financial assistance, unless otherwise noted for certain provisions in the terms and conditions of award, allowing agencies to customize their other transaction agreements to help meet project requirements and mission needs.

[9]A negative result is one that does not support the original hypothesis of an experiment. According to a 2019 National Academies of Sciences, Engineering, and Medicine (National Academies) report, reporting negative results can be meaningful to the scholarly record, although scientific journals prefer to publish statistically significant positive results. National Academies, *Reproducibility and Replicability in Science* (Washington, D.C.: 2019). For more information about efforts to improve the reliability of federal research, see GAO, *Research Reliability: Federal Actions Needed to Promote Stronger Research Practices*, GAO-22-104411 (Washington, D.C.: July 28, 2022).

and deliverables, is used less frequently than financial assistance to fund basic and applied scientific research.

Contracts and federal financial assistance for scientific research are usually awarded on a competitive basis. The federal government announces the funding opportunity publicly, and researchers then submit proposals for evaluation. Once award recipients have been selected, the federal government is to monitor their performance of the research to ensure that they are meeting any necessary requirements including compliance with applicable policies and procedures, such as those governing research involving humans or animals. Scientific program managers are the federal officials most directly responsible for ensuring that this process functions correctly and benefits both the funding agencies and the federal R&D enterprise.

Scientific Program Managers' Duties

Scientific program managers are responsible for agencies' research programs, which, broadly speaking, are any research activities that agencies undertake with a common scientific purpose. Research programs often consist of groups of individual research projects that an agency funds, either internally or externally.

An individual program manager may be responsible for a portfolio of multiple programs in their area of expertise. For example, a program manager at NASA might oversee a portfolio of programs related to planetary science, with each program consisting of several funded projects at different universities or laboratories.

A typical research program begins with the development of a topic area, then moves to the solicitation of proposals from researchers, project selection, and monitoring of the performance of awarded projects. Federally funded research projects may lead to further avenues of scientific exploration, or transition to further stages of technological development. Scientific program managers play an important role in each of these stages, and in coordinating among stakeholders both within and outside their agencies throughout the life cycle of the program.

Scientific research programs are distinctive because of the technical expertise needed to administer them appropriately. For this reason, we found that program managers who oversee basic and applied research at federal agencies are not normally hired under the Office of Personnel

Management (OPM) program management job series.[10] Instead, they are hired primarily as specialists in their fields of science or engineering, with the management of research programs as one of the major tasks that they perform. For example, while NSF uses "Program Director" to describe their program managers' function within the agency, the program managers' official position titles, such as "Physical Scientist" or "Astronomer," are based on their area of expertise.

The number of scientific program managers employed across the federal government who manage basic and applied research is not well understood. Some of the selected agencies did not provide an exact number for the number of program managers they employ. This is, in part, because program managers' position titles are based on their specific area of expertise and their responsibilities may or may not include managing basic and applied research. In addition, agencies may not have full inventories of the programs they administer.[11]

Program managers' responsibilities and priorities vary from agency to agency, and even within the same agency. For example, practices used by program managers overseeing transformational research may differ from those that oversee research that is more incremental.[12] In particular, program managers from the Defense Advanced Research Projects Agency (DARPA) and the Advanced Research Projects Agency-Energy (ARPA-E) are charged with seeking transformational research and empowered with the authority, responsibility, and ability to make program- and project-level decisions.[13] Regardless of such differences, most scientific program managers at the selected agencies are involved to some extent in the selection of research projects for funding awards, the

[10]According to OPM, Program Management Series 0340 covers all classes of positions whose primary duties are to manage or direct, or help manage or direct, one or more programs. A key qualifying requirement of such positions is management expertise. These positions do not require competence in a specialized subject or functional area. OPM, *Position Classification Flysheet for Program Management Series, 0340* (Washington, D.C.: May 2019).

[11]See GAO, *Improving Program Management: Key Actions Taken, but Further Efforts Needed to Strengthen Standards, Expand Reviews, and Address High-Risk Areas*, GAO-20-44 (Washington, D.C.: Dec. 13, 2019).

[12]Transformational research, which aims to produce major changes in scientific paradigms, generally entails higher risks corresponding to its higher potential rewards over a given span of time.

[13]DARPA is a component of DOD. ARPA-E is a component of DOE.

monitoring of awarded projects, and coordination with a wide range of stakeholders both inside and outside of their respective agencies.

Selection

Program managers at most of the selected agencies identify topic areas in which their agencies may fund research and develop those topic areas into funding programs. Agencies where topic development is a core part of a program manager's work include DOD, DOE, EPA, and NIH.[14] Program managers may also take part in administrative planning for programs, for example, by preparing a program budget or developing a schedule.

Once an agency has chosen the topic and developed the plan for a program, the process of selecting research projects for funding begins with the issuance of an announcement that funds are available through the program. Program managers may also be responsible for ensuring that these announcements accurately reflect the needs and priorities of their agencies. Announcements are formally referred to as notices of funding opportunity, but may also be called funding opportunity announcements, broad agency announcements, program or research announcements, or solicitations.

At agencies where program managers do not regularly identify and develop new program topics, program managers may help refine existing program topics by crafting funding opportunity announcements to reflect new developments or trends. They may also be responsible for creating funding opportunity announcements that accurately reflect the scientific priorities identified by Congress or agency leadership.

All of the selected agencies have some form of merit review to evaluate proposals received in response to a funding opportunity announcement. Program managers at these agencies may manage various aspects of the review process. For example, their responsibilities may include identifying and recruiting qualified outside scientists to serve as reviewers for proposals. They may also organize and moderate panels where reviewers discuss proposals as part of the review process.

The level of program managers' involvement in the merit review process varies from agency to agency. For example, NIH uses a peer review process that is usually conducted without any involvement from program managers. Instead, specialized personnel, known as scientific review

[14]NIH is an operating division of HHS.

officers (SRO), manage the initial peer review process during award selection. SROs at NIH identify and recruit scientists to serve as members of review groups and assign proposals to those groups for review. They also organize review group meetings and facilitate and document the discussion of proposals at those meetings. They record the scores that reviewers assign to proposals and prepare and release a statement that summarizes the scientific and technical merit of the application.

Not all of the selected agencies use formal peer review as part of their selection process for all programs. Namely, at DOD, peer review is mandatory for certain programs and optional for others. In programs where formal peer review is optional, DOD program managers may solicit input and expertise from other scientists on submitted proposals, or they may rely on their own scientific expertise to determine which projects to fund.

At agencies that conduct formal peer review of proposals, program managers may or may not have input into which proposals ultimately receive funding. At NIH, for example, proposals are funded in rank order based on reviewer scores.[15] At some agencies, however, including NSF, DOE, VA, NASA, and EPA, program managers may provide context or add other input to agency leadership, who consider reviewer scores or evaluations when making the final funding decisions. DOD program managers generally have final discretion to determine which proposals to fund.

Monitoring

Once recipients receive funding, they must submit reports on a regular basis detailing the scientific progress of their research. These reports may include an annual progress report such as the Research Performance Progress Report (RPPR), a uniform format used by federal agencies that fund research, including NIH, DOE, VA, and NASA. When required, funded researchers generally submit RPPRs annually while their projects are ongoing and a final RPPR when the project has ended. Program managers may also be responsible for reviewing RPPRs.

Funded researchers must also meet a variety of administrative requirements set by either the federal government or individual funding agencies. These may concern, for example, ethical responsibilities such

[15]NIH program managers may recommend funding lower-ranked proposals after providing appropriate justifications tied to factors documented in the notice of funding opportunity.

as ensuring the well-being of human and animal research subjects. They may also pertain to publishing, such as requirements for open-access reporting of research results, or acknowledgement of agency sponsorship in publications. Program managers from some agencies monitor compliance with such obligations as funded researchers carry out the scientific work for which they received an award.

Program managers at the selected agencies may also be responsible for overseeing certain aspects of how funded researchers use funds.[16] In particular, program managers may be required to track expenditure rates (how quickly funded researchers spend awarded funds.) In these cases, agencies are using expenditure rates as a measure of the timeliness and progress of funded researchers.

Coordination

As experts in their scientific fields, program managers are responsible for coordinating with agency leadership to help ensure that programs meet the agencies' missions and goals and that leadership has accurate scientific information available for decision-making. For example, program managers may provide information to agency leadership to assist them in making funding decisions.

Program managers may be responsible for coordinating with their peers both within their own agencies and at other agencies. This coordination helps to avoid unnecessary duplication and overlap in agency research programs across the federal government.

Program managers may also communicate with non-federal entities and the public about the research they are funding. For example, they may maintain connections with the scientific community to help ensure that their programs reflect current developments in science and that potential researchers and reviewers are aware of agency programs. Program managers may also communicate with the public about their agencies' missions and programs, including the results of research that agencies fund. For example, program managers may prepare written materials for public websites and press releases. At some agencies, such as DOD and DOE, program managers help funded researchers to identify opportunities for follow-on research or the transition of scientific results to the stage of experimental development.

[16]Some program managers, such as NIH's scientific review officers, do not monitor projects.

For more information about the management of basic and applied research at our selected agencies, see appendix I.

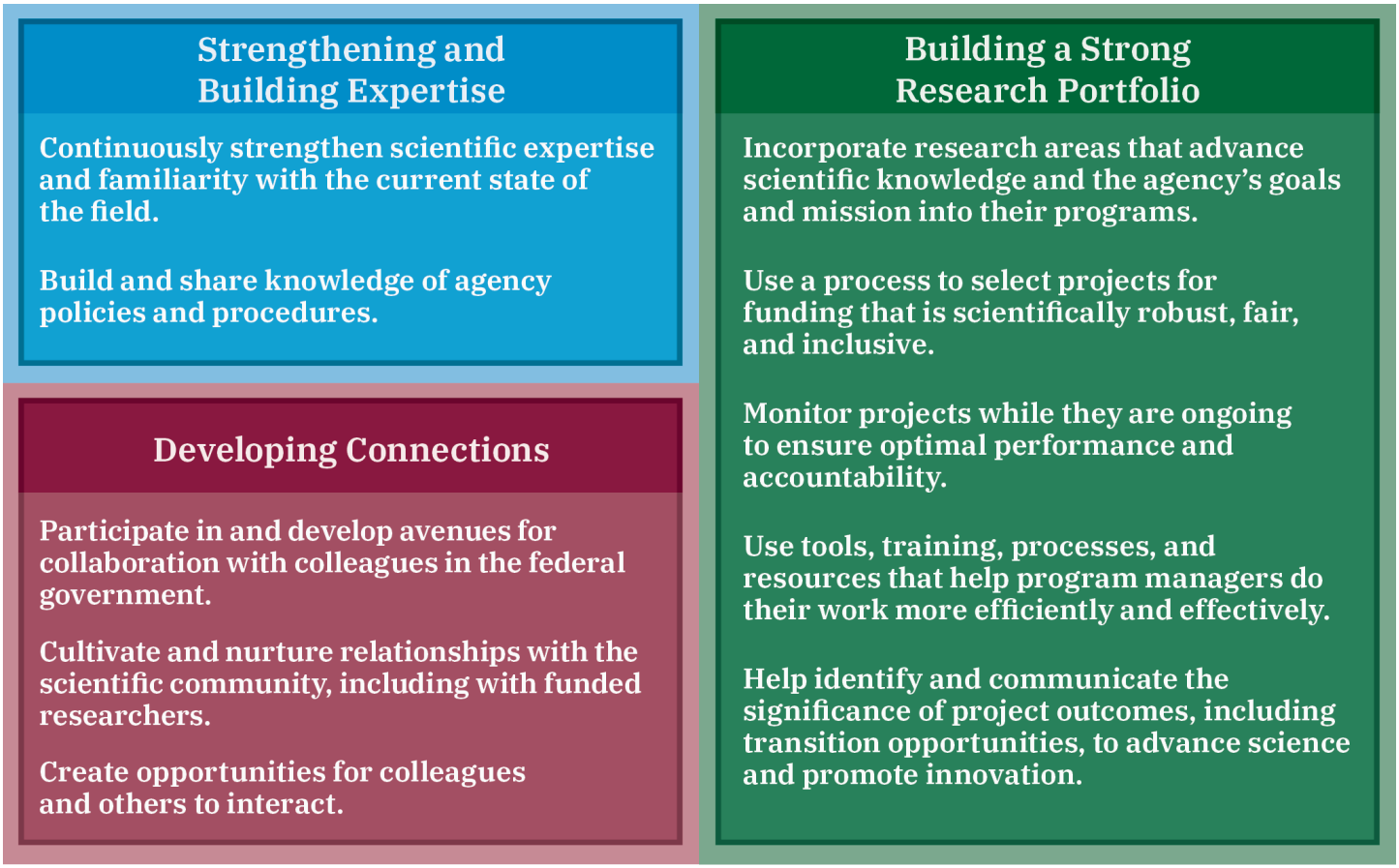
Key Practices and Considerations for Program Managers of Federal Scientific Research

Key practices that federal program managers use to effectively implement processes for selecting, monitoring, and coordinating basic and applied research fall into three areas:

- Strengthening and building expertise—Practices that help program managers maintain scientific and management expertise.
- Developing connections—Practices that help program managers enhance collaboration with the scientific community and the public, as well as colleagues and leadership within their own agencies and in other agencies.
- Building a strong research portfolio—Practices that help program managers advance their agencies' research mission and scientific knowledge in general, while ensuring their own accountability and that of federally funded researchers.

We describe below in more detail 10 key practices, by area, that federal program managers use to help them select, coordinate, and monitor federal research at their agencies (see fig. 1). We also provide examples of how various federal agency program managers have implemented these practices. For each area, we also describe considerations that program managers may take into account when seeking to implement these key practices.

Figure 1: Key Practices Used by Federal Program Managers to Select, Coordinate, and Monitor Scientific Research



Sources: GAO analysis of discussions with scientific program managers. | GAO-24-106297

Strengthening and Building Expertise

Program managers told us that they are active participants in the scientific process. They seek to advance the missions of their agencies as well as scientific knowledge more generally. They also said that, as managers, they need certain skills to nurture and guide scientific programs in accordance with their agencies' policies and procedures. The first two key practices relate to how program managers can strengthen and build their scientific and management expertise.

Program managers told us that they should be experts in their scientific field. This includes keeping up on new developments and trends, so they can identify research areas where their agencies could productively invest and potentially "sunset" less-productive research. Program managers noted they continuously strengthen their scientific expertise and stay up to date on the latest advances in their field by attending conferences and following the scientific literature.

The program managers cited the following examples:

- DOD program managers told us that going to conferences, engaging with researchers, and learning about the latest developments in their field of research is one of the most important aspects of their job. One DOD program manager added that it may take years before new ideas appear in the scientific literature, so hearing presentations at conferences may be essential to staying up to date on the latest research.
- An NIH program manager told us that workshops and scientific meetings help program managers maintain scientific expertise and connection with their field. Another NIH program manager said that a

key practice is maintaining the expertise needed to identify gaps in a scientific field, and projects that may help fill those gaps while advancing the missions of their organizational units.

- An NSF program manager told us they have organized workshops focused specifically on uncovering new ideas in fields such as artificial intelligence and mathematics. The program manager also said they attend conferences to do outreach with the scientific community and learn about the latest developments in their areas of research. The program manager said keeping up on the latest research helps them be more responsive to their agency's needs.
- EPA program managers described enlisting specialists to participate in writing teams to draft funding opportunity announcements and to take part in project review meetings. A program manager added that most EPA program managers are generalists who understand broad scientific concepts and because EPA grants can be very specific, having specialists on the writing team to ask questions and provide feedback is very helpful.
- An NSF program manager described the importance of stepping outside of their immediate scientific field to see how experts in a range of fields are talking about different topics. The application of artificial intelligence, for instance, is being discussed very differently in business circles than psychology and sociology circles. The program manager said having a good blend between internal conversations and external conversations is important.

Program managers told us they should continuously seek to improve their knowledge of agency policies and procedures, and mentor newer program managers by sharing such knowledge. They said program managers can take the initiative to build knowledge of their agencies' documented policies and procedures and take advantage of training and resources available through their agencies to help them expand their management knowledge base. They can also mentor new program managers and help them learn day-to-day administrative processes.

The program managers cited the following examples:

- DOE program managers told us that it is important to establish good working relations with other DOE staff such as grants officers. They added that experienced program managers should introduce new program managers to staff such as grants officers and demonstrate how best to work with them.
- NSF program managers also described NSF's training for their external peer review panelists as an example of sharing knowledge of agency policies and procedures. They said this training covered topics such as NSF's merit review criteria of intellectual merit and broader

impacts, conflicts of interest, and managing bias during the review process.

- An NSF program manager told us that NSF's standard operating procedures help them to do their jobs with objectivity and fair-mindedness. For example, NSF officials told us that these procedures state that program managers are to document how they sought diverse perspectives in review panels.
- A VA program manager told us that program managers must be proficient both in managing scientific research and in managing people. The program manager said it can be beneficial for program managers to have training in areas as diverse as federal budgeting and ethics, as well as topics such as human-subject and animal treatment trials.

Considerations when Implementing Practices That Help Strengthen and Build Expertise

Program managers said that they may seek the expertise of colleagues and the research community when portfolio topic areas are so broad that it can be difficult for a program manager to fully understand all aspects of them or when a research topic is beyond a program manager's base of knowledge.

Source: GAO group discussions with program managers | GAO 24 106297

Developing Connections

Program managers told us that much of what they do involves bringing people together, listening to them, and sharing ideas. They said that developing connections with people within academia and industry, as well as with program managers and leadership in their agencies and other federal agencies is an integral part of their work. These connections can help them learn of current developments in science, better understand the progress of funded projects, avoid unnecessary overlap and duplication in research funding, gain insight into the needs of the potential users of research, and facilitate the transition to follow-on research or commercialization.

Program managers also told us they actively seek to build connections with underrepresented voices to ensure that they capture the breadth of scientific viewpoints. Within their agencies, they said these connections can help them obtain the buy-in of agency leadership to new ideas and develop their agencies' program management workforce.

Program managers told us that collaborating with colleagues in their agency and at other federal agencies help them track what others are doing and prevent unnecessary duplication of efforts. It can also help them to identify ways in which different agencies' efforts may complement each other. Such collaboration can take place in formalized settings such as working groups or communities of practice, or through informal means like seeking out counterparts from other federal agencies at conferences.

Examples cited by program managers included the following:

- A DOD program manager said they conduct departmental research initiatives where 10 to 15 individual project teams working in a similar area, such as a specific aspect of the ocean sciences, meet two to three times per year. Much of the program manager's time is spent facilitating the connections and coordination involved in these research initiatives. The program manager said that these meetings also help with monitoring because they require meeting regularly with their funded researchers.
- DOE program managers described developing relationships across DOE offices, other agencies, and in some cases internationally, to

help them identify technology gaps and avoid duplication of projects in their fields. The program managers emphasized that taking the initiative to speak to their counterparts regularly is part of their role.

- An EPA program manager said establishing trust with their senior leaders is critical to writing solicitations and developing funding announcements. Maintaining good relationships with EPA leadership helps with securing funding and having staff with the right skills assigned to the teams who write funding announcements. The EPA program manager also said that early and continuous involvement in internal EPA professional organizations and communities of practice is highly valuable to their work.
- NASA program managers described coordinating across NASA divisions and with NSF on exoplanet research.[17] They said coordination with NSF on exoplanet research is especially important because NSF funds ground-based observations and NASA funds space-based observations, and exoplanet research relies on resources and knowledge from both agencies.
- An NIH program manager told us that it is important to participate in NIH-wide committees to prevent unnecessary duplication of efforts.[18] Another NIH program manager stated that coordinating across NIH may help with achieving economies of scale if multiple NIH institutes and centers work together. An NIH program manager also said that coordinating with DOD and VA helps prevent duplication of efforts because there are certain topics that are more appropriate for one agency over another to fund.
- An NSF program manager told us it is not uncommon for NSF program managers to participate in 10 or more agency-wide working groups on specific research areas. Participating in these working groups helps program managers recognize overlaps and discuss ways to improve their reach to broader segments of the scientific community. Further, another NSF program manager noted that working groups provide program managers with opportunities to interact with colleagues in different scientific fields and share knowledge on program management.

[17]Exoplanet research is the discovery and understanding of planetary systems around nearby stars.

[18]See GAO, *Biomedical Research: Actions Needed to Adopt Collaboration Practices to Address Research Duplication*, GAO-24-106757 (Washington, D.C.: Feb. 29, 2024).

Program managers said that establishing and maintaining collaborative relationships with the scientific community can lead to better quality research proposals and help improve research outcomes. They described cultivating relationships through informal means, such as direct personal outreach, as well as more formalized settings like workshops. They also described reaching out to potential researchers at conferences and other events to help them build larger and more diverse networks.

Examples cited by program managers included the following:

- DOD program managers told us that, while they must refrain from interfering with the work of the researchers they fund, communicating periodically with those researchers allows them to act as a sounding board when problems arise and help determine next steps that will benefit the researchers, funding agencies, and students and post-doctoral researchers.
- VA program managers told us they try to build relationships with funded researchers. They said it was more efficient for researchers to reach out to program managers when encountering difficulties rather than to wait and disclose the problems in a required report and potentially after mitigations could have been implemented.

- An EPA program manager said they hold a “kick-off” meeting for each funding cycle to introduce the funded researchers to one another and to EPA researchers. These meetings allow researchers to share ideas and help integrate their studies with other EPA research efforts.
- An NIH program officer described the importance of providing feedback to researchers after receiving written reviews on their research proposal from reviewers. The program manager said they read many summary statements and reviews, so that they can advise researchers on how to understand and respond to reviewer comments. Even when applications are not funded, helping applicants understand the review feedback enhances their chances for future success.
- An NSF program manager stated that meeting with researchers, particularly during site visits at universities, gives them a chance to interact with people who generally are not available to travel such as students and post-doctoral researchers. On-site meetings also allow them to directly observe the condition of the laboratories.

Developing Connections

Program managers told us that they create opportunities to bring various communities, including underrepresented groups, together to spur development of new ideas and approaches to address problems. Through building these connections within their own communities or across communities, they can help funded researchers from different institutions connect to share research ideas or help members of the scientific community connect with a broad range of agency officials to understand the agency's research needs.

Examples cited by program managers included the following:

- A DOE program manager from ARPA-E said that they seek out colleagues from other DOE offices to understand what they do and where there is potential for overlap. While some overlap may be unavoidable, communicating with colleagues from other DOE offices can help them see when there is a need to reposition their programs. The program manager stated that some of the DOE colleagues they have met through these outreach efforts have become reviewers for some of their projects.

Considerations when Implementing Practices That Help Develop Connections

Program managers said that while building networks and interacting with funded researchers, they must be cognizant of both agency policies and procedures to avoid favoritism and conflicts of interest.

During the COVID-19 pandemic, many meetings were moved to virtual settings, which some program managers said hampered their ability to interact with and learn from their peers. However, other program managers noted that virtual conferences allowed some researchers to attend conferences that they typically could not participate in because of resources or other constraints.

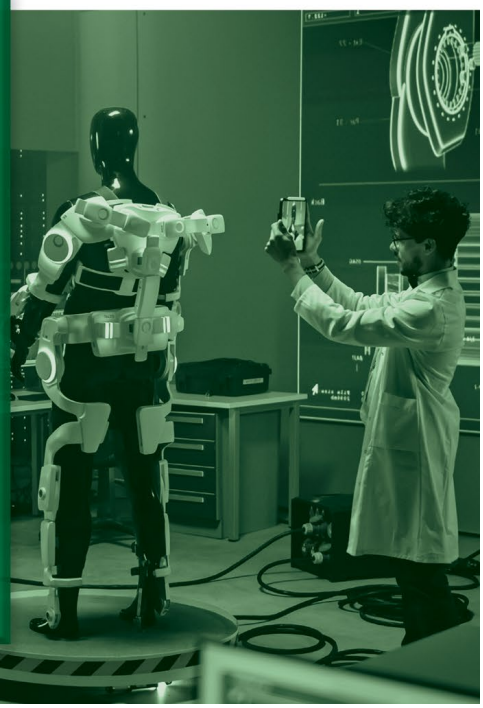
Source: GAO group discussions with program managers | GAO-24-106297

- An EPA program manager told us they held a workshop to share project plans and results from research grants from multiple solicitations on per- and polyfluoroalkyl substances (PFAS) and invited other agencies, such as the U.S. Department of Agriculture and U.S. Geological Survey, to participate. They said the workshop helped identify gaps in research and gave EPA's researchers ideas for refining their study designs.
- An NSF program manager told us that meetings with funded researchers are increasingly becoming a requirement in their funding agreements. They have found that these meetings enhance coordination among researchers and improve the quality of research.
- VA program managers described holding an internal workshop to seek solutions regarding amputation rehabilitation that brought together outside researchers specializing in a variety of fields such as cellular therapeutics, cartilage regeneration, and muscle atrophy.

Building a Strong Research Portfolio

Program managers told us that their job is to ensure they are building scientific research portfolios that advance the mission of their agency as well the underlying science. For program managers, this could include shaping potential areas of study and developing funding opportunity announcements, selecting the best proposals for funding, overseeing ongoing projects and keeping them on track, and identifying follow-on research or commercialization opportunities. They told us that taking full advantage of available tools, training, and resources helps them manage their workloads.

Incorporate research areas that advance scientific knowledge and the agency's goals and mission into their programs.



Program managers told us that they draw on their scientific expertise and communication with both the scientific community and potential users of research to guide the identification of areas that bridge gaps in scientific knowledge and meet their agencies' research goals and incorporate those areas into their programs. We spoke to high-level science policy officials who said federal agencies should seek to develop a balanced portfolio of transformational and incremental research opportunities. Program managers said they can develop new funding opportunities and solicitations to explore new research areas or modify existing funding opportunities to build on past research. They may also encourage the scientific community to set research directions by avoiding being overly prescriptive in how they word solicitations.

Examples cited by program managers included the following:

- A DOE program manager in the Office of Science said that for DOE's isotope program, they need to be responsive to world events including supply chain dynamics and other conditions when developing areas in which to conduct research. Another DOE program manager stated that although many areas of research are already set within the Office of Science, program managers must determine what topics within

these areas remain relevant and how to adjust programs to keep them current. For example, DOE Office of Science officials said its program managers help update its funding opportunity announcements each year, by drawing on both published advancements in the field and conversations with stakeholders in the scientific community. These updates help mitigate programmatic stagnation, draw attention to programmatically relevant and evolving subjects within each scientific area, and allow for the funding of cutting-edge science.

- An EPA program manager stated that when developing requests for research applications, they must incorporate considerations from other EPA programs and regional offices and ensure that solicitations align with agency-wide strategic plans regarding priorities for research topics.
- A NASA program manager said the agency relies on Decadal Surveys prepared by the National Academies of Sciences, Engineering, and Medicine as a guide to which scientific areas to fund. Program managers must consider how best to accommodate the priorities recommended by the Decadal Surveys within their existing programs.
- An NIH program manager stated that some NIH institutes and centers hold retreats where program managers can propose program ideas, and then a few are selected to be developed. The program managers must align their ideas with the goals of their institutes and centers, because in proposing new program ideas, program managers are competing for limited funding across the agency. To be successful, they must get multiple levels of leadership to buy into their program proposals.

Federal guidance, including OMB's *Uniform Administrative Requirements, Cost Principles, and Audit Requirements for Federal Awards*, require that agencies use a fair and transparent process to select projects for funding.[19] Program managers told us they work to fully implement this, as well as their agency's policies and procedures, as part of their efforts to fund the highest quality research projects. They said they sought to recruit and manage a knowledgeable and unbiased review panel with diverse viewpoints.[20] They said they assessed potential biases and conflicts of interest in potential reviewers by familiarizing themselves with their research and publications, and soliciting input from peers. Furthermore, they said that they try to maintain good relationships with a large pool of potential reviewers to help them find and recruit qualified and diverse reviewers. They also said that transparency in the review

[19]2 C.F.R. § 200.205, and App. I to Part 200 (2023).

[20]Note that federal law, executive policy, and agency regulations also require agencies to be inclusive in awarding funding. For example, under Exec. Order No. 13985, agencies must promote equitable delivery of government benefits and equitable opportunities, including for government contracting and procurement opportunities. Exec. Order No. 13985, *Advancing Racial Equity and Support for Underserved Communities Through the Federal Government* (Jan. 20, 2021), 86 Fed. Reg. 7009 (Jan. 25, 2021).

process can help applicants understand why their proposal was or was not selected.

Examples cited by program managers included the following:

- A NASA program manager told us that, regardless of whether they are developing new solicitations or modifying existing calls for proposals, they must consider how the field has changed and how practices in the scientific community may have changed. The program manager also said that NASA is now more aware of the importance of selecting projects led by investigators with a range of experience levels. NASA's selection process emphasizes not only the state of science and technology, but also what is important for the scientific workforce they are supporting.
- An NIH scientific review officer (a specialized NIH program manager who manages the project selection process) told us that they are trained to maintain the integrity of the review process and align it with policy. One of their most important tasks is recruiting a strong and diverse review panel that will conduct a robust discussion during its meeting and ensure that NIH is funding the right projects.
- An NSF program manager told us that selecting reviewers who are objective, complementary, and comprehensive is important. Because NSF relies on external peer reviews for most awards, program managers need to include a variety of viewpoints, particularly from underrepresented groups.

  Similarly, another NSF program manager said that having a balanced mix of researchers and institutions could ensure a diverse set of perspectives. The program manager added that, for example, research should not always be driven by the same small group of universities. An NSF program officer told us that they may calibrate peer review scores to account for the relative differences in how individual reviewers score research proposals. By calibrating the reviewers, they can better compare the scores of different proposals and reviewers.

- VA program managers said they aim to recruit reviewers with a diverse spectrum of backgrounds, expertise, and perspectives; to see where the gaps are; and to recruit to fill those areas. They discussed bringing in new reviewers and pairing them with more experienced reviewers on the review panel. They also discussed bringing in a mixture of expertise, such as having biostatisticians, gerontologists, or

specialists on clinical trials serve on the same panel. In particular, they include clinicians on the panels to ensure that veterans' health needs are the primary focus of evaluations.

Program managers told us that they actively monitor the projects and programs they manage so they can help researchers solve problems, if needed, and ensure their own accountability as stewards of public funds. In addition, they said they maintain regular communication with researchers using both formal and informal avenues.

Program managers described using a wide variety of evaluation criteria and their scientific expertise to assess progress and outcomes. In addition to monitoring the progress of the research they manage, they also said they can assess and document various aspects of their own work.

Examples cited by program managers included the following:

- A DOD program manager told us that in monitoring projects, program managers are responsible for ensuring funds are used within what the agency has defined as a reasonable amount of time. If a researcher is not spending the money as quickly as they had originally planned, a program manager could request more information and approach the situation with flexibility. For example, if a project is not using the funds at an expected rate, it may be because of delays in equipment

delivery or staff departures, such as when a student researcher graduates.

- An EPA program manager cautioned against simply assessing the use of funds to gauge progress. For example, a grant that requires purchasing equipment may spend a significant amount of money up front, while other research projects may take longer to begin spending funds.
- An NSF program manager tells researchers to focus in their annual reports on problems encountered that may signal opportunities for the program manager to help. For example, one study was delayed because a student suffered an accident and was confined to a wheelchair and could not operate an instrument used in the research. In response, NSF provided supplemental funding through a program designed for accessibility of research to scientists with disabilities that allowed the injured student to resume working and complete the research.

Program managers told us they juggle multiple competing demands on their time, and that they take advantage of all available resources to help them manage their workloads. They described using available project management tools and training provided by the agency and actively cultivating relationships with agency staff who can help facilitate project management tasks. We spoke to high-level science policy officials who emphasized the importance of providing administrative support to program managers, such as on contracting and accounting. They said that without adequate support, program managers can get bogged down in administrative tasks rather than supporting the researchers they are funding.

Examples cited by program managers included the following:

- A DOE program manager stated that DOE Office of Science's Consolidated Service Center helps them with the administrative side of grants management. The Consolidated Service Center provides professional services in Office of Science facilities across the U.S., including financial evaluation, procurement and contracts, and information management. For example, DOE Office of Science officials said that when a funded researcher asks to reallocate funds

from one area of their study to support additional experiments, a technical assessment by the program manager is required along with the approval of the contracting officer from the Consolidated Service Center.

- A NASA program manager said the agency uses the NASA Shared Services Center to check whether projects' use of funds is appropriate and compliant with applicable rules and regulations. The program manager said that the Shared Services Center will alert them if they identify potential problems. For example, a program manager will be contacted to reauthorize very large expenditures. Program managers told us they can issue exceptions to certain rules and regulations.
- A NIH program manager described NIH's Research Portfolio Online Reporting Tools - Expenditures and Results (RePORTER) database as being very helpful in tracking the projects they fund. RePORTER is an electronic tool that allows users to search a repository of NIH-funded research projects and access publications and patents resulting from NIH funding.[21]
- An NSF program manager said that tools such as Research.gov can help program managers monitor the projects that they manage, such as expenditures and rates at which funds are being spent (burn rates).[22] Research.gov also helps researchers track the status of their proposals.
- A VA program manager said they use PubMed alerts when reviewing progress reports to make sure researchers are acknowledging VA funding in their publications per VA requirements.[23] The program manager also checks the Dimensions database for projects that might have transitioned to further stages of development and see whether patents resulting from the research have been issued.[24]

[21]https://reporter.nih.gov, accessed February 12, 2024.

[22]https://www.research.gov/research-web, accessed February 16, 2024. Research.gov is an online platform that provides grants management for the NSF research community.

[23]https://pubmed.ncbi.nlm.nih.gov, accessed February 12, 2024. PubMed is an online database maintained by the National Center for Biotechnology Information at NIH that contains over 36 million citations and abstracts of biomedical literature.

[24]https://www.dimensions.ai, accessed February 12, 2024. Dimensions is a private-sector research database that covers publications, grants, patents, clinical trials, datasets, and policy documents.

Program managers told us they communicate the results and potential impacts of the programs they manage to advance science and promote innovation. They said communicating results helps shape agency research priorities, determine paths for possible follow-on research, and spur innovation and opportunities for commercialization among researchers and industry. Project managers told us they do this by seeking appropriate forums to share results of funded research, such as agency workshops or international scientific conferences. They also emphasized building communications skills to help tailor messages to a variety of audiences, including agency leadership, Congress, and the public.

Examples cited by program managers included the following:

- A DOD program manager from DARPA said that program managers should think about and be able to communicate the effects the completed research may have on the U.S. military or society more broadly. DOD officials told us this is important because an important part of a program manager's job is identifying ways that planned technologies could be transitioned to follow-on research or commercialization. They must be able to communicate to potential

transition partners such as laboratories and businesses about how research could translate either to new avenues of basic research or to help make technologies that will meet DOD's needs.[25]

Considerations When Implementing Practices That Help Build a Strong Research Portfolio

Program managers said that not all good ideas for programs and projects receive funding. This may occur because the ideas do not align with an agency's current priorities or because of limited outreach and communication between program managers and researchers.

Source: GAO group discussions with program managers | GAO 24 106297

- A NASA program manager stated that the agency considers advancing development of a technology to be a measure of success. For its technology programs, NASA archives all projects' successes and makes this information available to other agencies and the public through the agency's TechPort database.[26]
- After completion of projects, an NIH program manager said researchers may apply for new funding to extend or redirect the research. Program managers should be prepared to help these researchers assess their next steps. Another NIH program manager said some grants involve long-term projects where researchers will communicate with the program managers on possible follow-on research. This process gives the program manager a view of the long-term success and outcomes of these grants.

Agency Comments

We provided a draft of this report to the Department of Defense, Department of Energy, Department of Health and Human Services, Department of Veterans Affairs, Environmental Protection Agency, National Aeronautics and Space Administration, and National Science Foundation for their review and comment. All seven agencies provided technical comments, which we incorporated, as appropriate.

We are sending copies of this report to the appropriate congressional committees; the Secretaries of Defense, Energy, Health and Human Services, and Veterans Affairs; the Administrators of the Environmental Protection Agency and National Aeronautics and Space Administration; the Director of the National Science Foundation; and other interested parties. In addition, the report is available at no charge on the GAO website at https://www.gao.gov.

[25]In 2015, we identified four factors that contributed to transition success at DARPA, including military or commercial demand for the planned technology and active collaboration with potential transition partners. See GAO, *Defense Advanced Research Projects Agency: Key Factors Drive Transition of Technologies, but Better Training and Data Dissemination Can Increase Success*, GAO-16-5 (Washington, D.C.: Nov. 18, 2015).

[26]https://techport.nasa.gov/home, accessed February 12, 2024. NASA's TechPort database contains information on NASA's portfolio of active and completed technology projects, which can help facilitate opportunities for collaboration and partnerships and analyses of how the agency is meeting its mission.

If you or your staffs have any questions about this report, please contact me at (202) 512-6888 or WrightC@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. GAO staff members who made key contributions to this report are listed in appendix II.

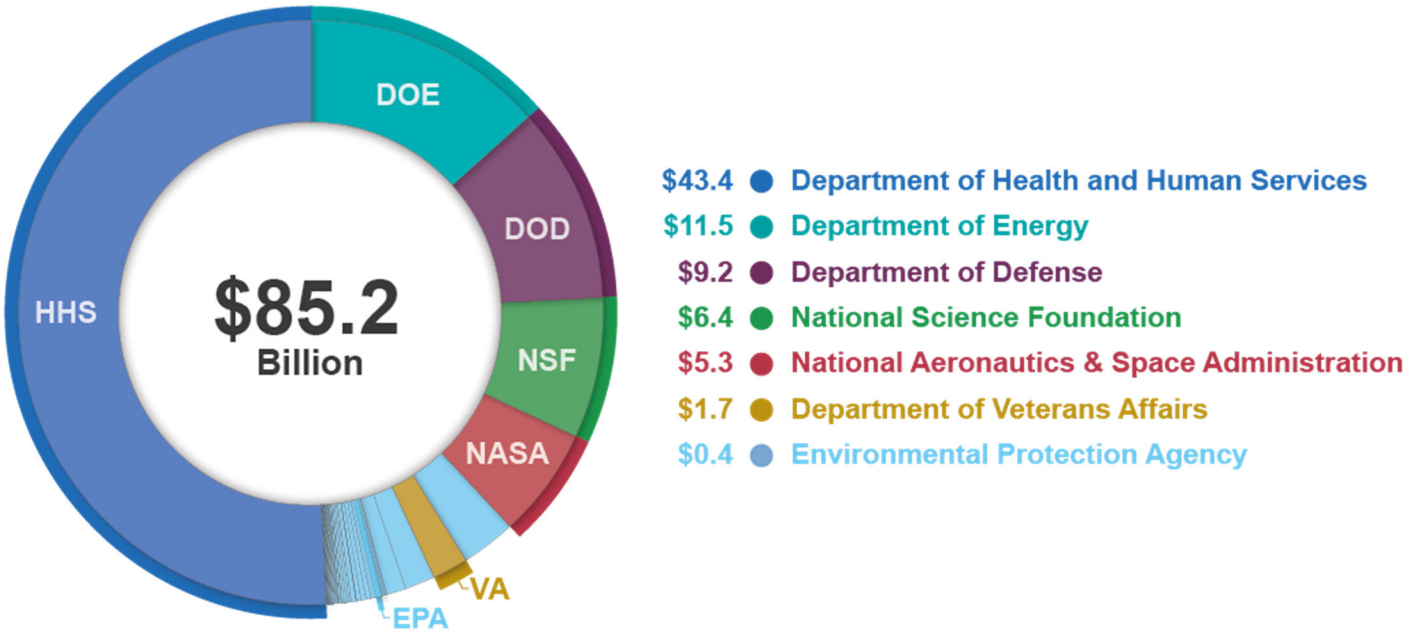
Candice N. Wright
Director
Science, Technology Assessment, and Analytics

Appendix I: Summary of Funding, Organizational Structure, and Research Program Manager Responsibilities

This appendix provides additional information on our seven selected agencies—the Department of Health and Human Services (HHS), Department of Energy (DOE), Department of Defense (DOD), National Science Foundation (NSF), National Aeronautics and Space Administration (NASA), Department of Veterans Affairs (VA), and Environmental Protection Agency (EPA)—including information on agency basic and applied research obligations, primary agency components that conduct research, and the number and role of program managers. We selected these seven agencies primarily based on the amount of funds they obligated for basic and applied research. Five of these agencies—HHS, DOE, DOD, NSF, and NASA—obligated nearly 90 percent of federal research funding in fiscal year 2021, according to the National Science Foundation's estimates in its Survey of Federal Funds for Research and Development.[1]

[1]An obligation is a definite commitment that creates a legal liability of the government for the payment of goods and services ordered or received, or a legal duty on the part of the United States that could mature into a legal liability by virtue of actions on the part of the other party beyond the control of the United States. An agency incurs an obligation, for example, when it places an order, signs a contract, awards a grant, purchases a service, or takes other actions that require the government to make payments to the public or from one government account to another. GAO, *A Glossary of Terms Used in the Federal Budget Process*, GAO-05-734SP (Washington, D.C.: Sept. 2005).

Figure 2: Total Estimated Fiscal Year 2021 Basic and Applied Federal Agency Research Obligations, including for the Seven Selected Agencies



Source: GAO analysis of NSF data. | GAO-24-106297

Note: National Science Foundation, National Center for Science and Engineering Statistics, Survey of Federal Funds for Research and Development: Fiscal Years 2020–21. NSF 22-323 (Alexandria, VA: 2022). NSF referred to these FY 2021 data as 'preliminary' in survey documentation because these data were updated in the subsequent volume of the survey. We refer to the FY 2021 data as 'estimates' throughout this appendix.

Department of Health and Human Services

HHS's mission is to enhance the health and well-being of all Americans by providing for effective health and human services and by fostering sound, sustained advances in the sciences underlying medicine, public health, and social services. HHS has 12 operating divisions, with the National Institutes of Health (NIH) funding an estimated 95 percent of HHS's basic and applied research obligations in fiscal year 2021.

NIH is the federal focal point for health research and its mission is to seek fundamental knowledge about the nature and behavior of living systems and the application of that knowledge to enhance health, lengthen life, and reduce illness and disability

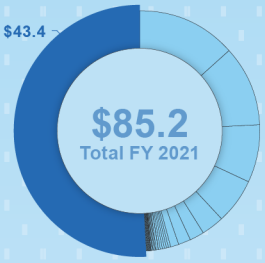
NIH Research Components NIH is made up of 27 Institutes and Centers, each with a specific research agenda, with some focusing on a particular disease, such as the **National Cancer Institute** and the **National Institute of Allergy and Infectious Diseases**; and others on specific body systems, such as the **National Eye Institute** and the **National Heart, Lung, and Blood Institute**. Twenty-four of the 27 NIH institutes and centers award extramural research. NIH, through its institutes and centers, acts as the federal focal point for health research.

NIH Program Managers The agency's more than 1,500 program managers (known within NIH as program officials, program officers, or project officers) are staff scientists who manage grant portfolios for extramural research. Their responsibilities include:

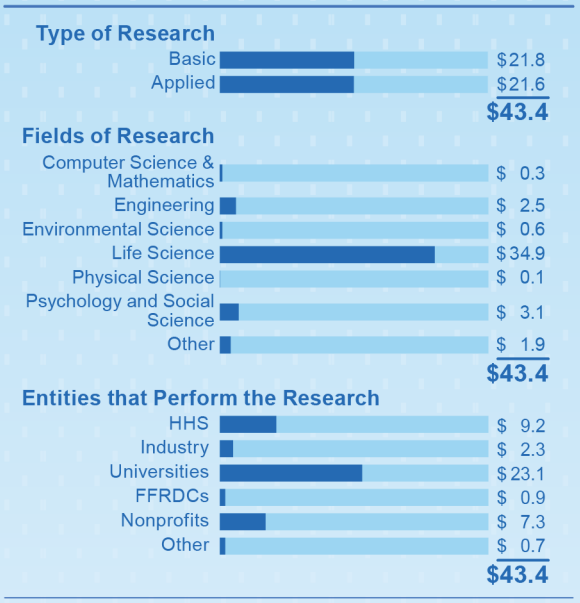
- Interact with the extramural grant recipient community to assess research needs and opportunities.
- Provide scientific expertise to their Institute or Center and other NIH components and federal agencies.
- Develop research concepts, requests for applications, program announcements, and notices of special interest.
- Facilitate investigator-initiated research by advising investigators on funding opportunities and how to apply for support.
- Administer scientific portfolios of grants and cooperative agreements from application receipt through assignment and peer review, to selection for award and subsequent monitoring of performance.
- Attend NIH peer review meetings.
- Work with scientific review officers and grants management staff, as appropriate.
- Monitor the programmatic, scientific, and technical aspects of a grant.
- Work in partnership with grants management staff on pre-award and post-award administration, including review of progress reports.

Agency Highlight NIH's Center for Scientific Review manages the major part of NIH's scientific peer review process to aid in the selection of the most meritorious science for funding by NIH institutes and centers. This center employs about another 275 personnel (known as scientific review officers) to help manage the peer review process.

HEALTH AND HUMAN SERVICES (HHS)
Research Obligations at a Glance (in billions)



HHS obligated about $43.4 billion for basic and applied research in FY 2021. HHS obligated the largest amount of funds toward basic and applied research across the federal government.



Source: GAO analysis of National Science Foundation data. | GAO-24-106297

Note: National Science Foundation, National Center for Science and Engineering Statistics, *Survey of Federal Funds for Research and Development: Fiscal Years 2020–2021*. NSF 22-323 (Alexandria, VA: 2022). NSF referred to these FY 2021 data as 'preliminary' in survey documentation because these data were updated in the subsequent volume of the survey. We refer to the FY 2021 data as 'estimates' throughout this appendix.

The "Other" category in the "Entities that Perform the Research" chart includes state and local governments and foreign research entities.

Totals may not add up because of rounding.

Department of Energy (DOE)

DOE's mission is to ensure America's security and prosperity by addressing its energy, environmental, and nuclear challenges through transformative science and technology solutions.

As a science agency, DOE plays an important role in the innovation economy. The Department catalyzes the transformative growth of basic and applied scientific research, the discovery and development of new clean energy technologies, and prioritizes scientific innovation as a cornerstone of U.S. economic prosperity.

DOE Research Components Funding for nearly all basic and applied research supported and managed by DOE is provided by the following DOE offices and the National Nuclear Security Administration (NNSA).

Office of Science is the lead office within DOE supporting fundamental research for energy production and security. In fiscal year 2021, the Office of Science obligated an estimated $5.3 billion for basic research, or nearly 50 percent of DOE's total research obligations.

Office of Electricity provides national leadership and conducts research to ensure that the Nation's energy delivery system is secure, resilient, and reliable.

Office of Energy Efficiency and Renewable Energy supports deployment or demonstration of technologies, such as showing viable pathways for decarbonization of energy infrastructure.

Office of Fossil Energy and Carbon Management is responsible for federal research, development, and demonstration efforts on advancing technologies to meet climate goals and minimize the environmental impacts of fossil fuel use.

Office of Nuclear Energy advances nuclear energy science and technology to meet U.S. energy, environmental, and economic needs.

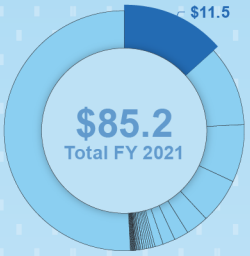
Advanced Research Projects Agency-Energy advances high-potential, high-impact energy technologies that are too early for private-sector investment.

NNSA is a separately organized agency within DOE that is responsible for enhancing national security through the military application of nuclear science. In FY2021, NNSA obligated an estimated $3.5 billion for basic and applied research, or about 30 percent of DOE's total research obligations.

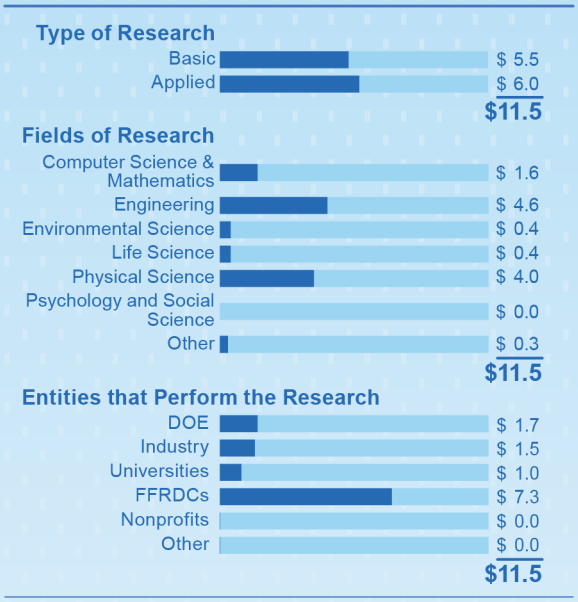
DOE Program Managers Over 700 program managers (known within DOE as program managers and program directors):

- Conceive, plan, and organize research programs, including budget planning.
- Share scientific expertise and provide technical analysis and input to leaders within and outside of DOE.
- Represent the agency to the scientific community through activities including participation in scientific meetings and conferences and the publication of written materials including reports and recommendations.
- Monitor projects and programs, identifying deficiencies, opportunities for improvement, and corrective actions when appropriate.

DEPARTMENT OF ENERGY (DOE)
Research Obligations at a Glance (in billions)



DOE obligated about $11.5 billion for basic and applied research in FY 2021: the 2nd largest amount obligated among the 32 federal government agencies.



Source: GAO analysis of National Science Foundation data. | GAO-24-106297

Note: National Science Foundation, National Center for Science and Engineering Statistics, *Survey of Federal Funds for Research and Development: Fiscal Years 2020–2021.* NSF 22-323 (Alexandria, VA: 2022). NSF referred to these FY 2021 data as 'preliminary' in survey documentation because these data were updated in the subsequent volume of the survey. We refer to the FY 2021 data as 'estimates' throughout this appendix.

The "Other" category in the "Entities that Perform the Research" chart includes state and local governments and foreign research entities.

Totals may not add up because of rounding.

Agency Highlight The Office of Science, the largest funder of basic research within DOE, is also the largest U.S. supporter overall of basic research in the physical sciences and is the steward of 10 of DOE's 17 National Laboratories.

Department of Defense (DOD)

DOD is the nation's largest government agency. Its mission is to provide the military forces needed to deter war and ensure national security.

DOD conducts and manages research to ensure continuous advancement of technology and innovation within the DOD enterprise.

DOD Research Components The Under Secretary of Defense for Research and Engineering serves as the primary advisor to DOD leadership on all matters pertaining to agency-wide research and development. The Basic Research Office, which is within the Office of the Under Secretary of Defense for Research and Engineering oversees DOD's basic research investments.

In fiscal year 2021, an estimated 88 percent of DOD's basic and applied research was funded by DOD's three military departments—the Air Force, Army, and Navy—and the Defense Advanced Research Projects Agency (DARPA)*:*

Air Force Research Laboratory seeks to discover, develop, and integrate affordable warfighting technologies for the U.S. air, space, and cyberspace forces. The Lab's **Air Force Office of Scientific Research** focuses on high-risk basic research.

U.S. Army Combat Capabilities Development Command (DEVCOM) oversees basic and applied research for the Army. Within DEVCOM, **Army Research Laboratory** funds basic and applied research to operationalize science to ensure an overwhelming advantage in any future conflict. Its **Army Research Office** manages the Army's extramural basic research program.

Office of Naval Research is tasked with discovering, developing, and delivering new technology and capability for the Navy and Marine Corps. Its **Naval Research Laboratory** conducts basic and applied research across a wide spectrum of scientific disciplines.

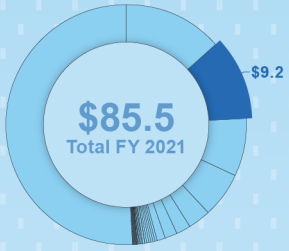
DARPA seeks to make pivotal investments that catalyze breakthrough technologies for national security.

DOD Program Managers Approximately 350-400 program managers manage basic and applied research programs (known within DOD and program managers and program officers).

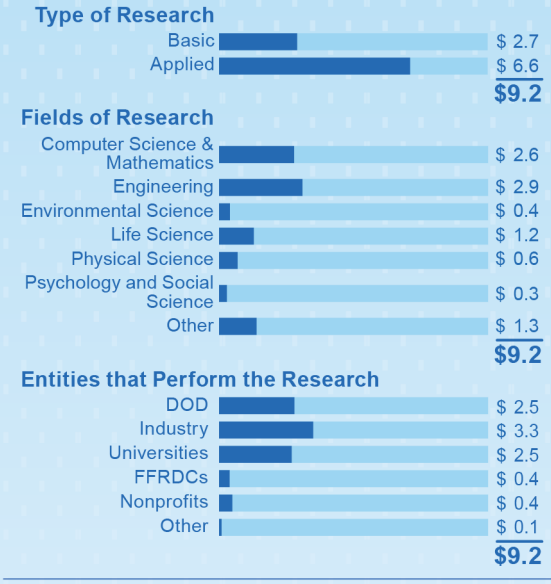
- Serve as topical and program experts within their division, DOD, and the wider scientific community.
- Set priorities for committing federal funds, acting as advocates for specific science areas.
- Define programs, meet with researchers, set milestones, and track the progress of projects to identify challenges and potential solutions.

Agency Highlight DOD program managers have considerable discretion in defining and selecting projects for awards. Program managers are empowered to redirect or sunset less productive research in response to the agency needs. This organizational model in which program managers have a high level of autonomy and decision-making authority **is** particularly noted at DARPA and referred to as the "DARPA model."

DEPARTMENT OF DEFENSE (DOD)
Research Obligations at a Glance (in billions)



DOD obligated about $9.2 billion for basic and applied research in FY 2021: the 3rd largest amount obligated among the 32 federal government agencies.



Source: GAO analysis of National Science Foundation data. | GAO-24-106297

Note: National Science Foundation, National Center for Science and Engineering Statistics, *Survey of Federal Funds for Research and Development: Fiscal Years 2020–2021*. NSF 22-323 (Alexandria, VA: 2022). NSF referred to these FY 2021 data as 'preliminary' in survey documentation because these data were updated in the subsequent volume of the survey. We refer to the FY 2021 data as 'estimates' throughout this appendix.

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Totals may not add up because of rounding.

National Science Foundation (NSF)

NSF's mission is to promote the progress of science; advance the nation's health, prosperity, and welfare; and secure the national defense.

NSF fulfills its mission primarily by funding research. According to NSF, during an average year, the agency funds over 11,000 new competitive awards that supports research at over 2,000 universities, colleges, and other institutions.

NSF Research Components The following eight NSF directorates fund basic and applied scientific research:

Biological Sciences supports research and education on the principles and mechanisms governing life — from cells to ecosystems and across space and time.

Computer and Information Science and Engineering supports research and education on the principles and uses of advanced computing, communications, information systems, and advanced cyberinfrastructure across science and engineering.

Engineering invests in engineering research and education and the development of innovations to benefit society.

Geosciences supports research and education on understanding and adapting to the changes in the earth, ocean, atmosphere, and polar regions.

Mathematical and Physical Sciences supports research and education in the astronomical sciences, chemistry, materials science, mathematical sciences, and physics.

Social, Behavioral, and Economic Sciences advances research and education on human behavior and social organizations and how social, economic, political, cultural, and environmental forces affect people's lives.

STEM Education invests in education and education research in STEM — science, technology, engineering, and mathematics — across age groups and settings.

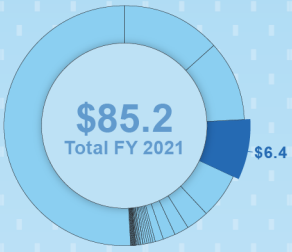
Technology, Information, and Partnerships advances critical and emerging technologies, accelerates use-inspired and translational research, and empowers Americans to participate in the U.S. research and innovation enterprise.

NSF Program Managers Over 600 program managers (known within NSF as program directors):

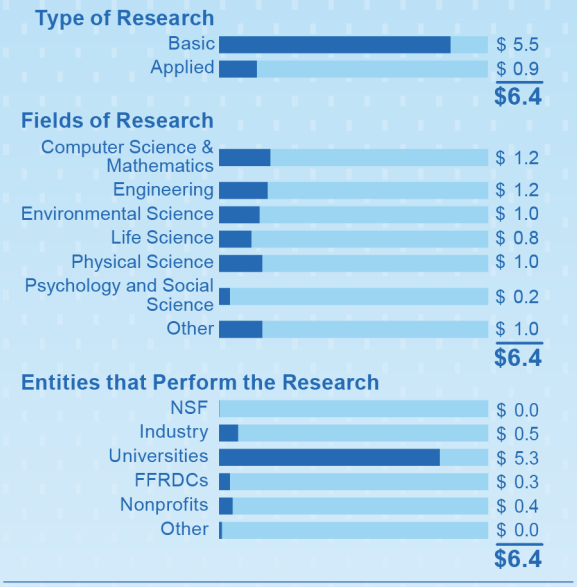
- Assist with planning and goal setting for NSF programs, including budget planning.
- Manage the review process for proposals, including recruiting a diverse pool of qualified reviewers. Advise on the selection of projects for funding, ensuring appropriate balance among scientific subfields and institutions.
- Monitor funded projects.
- Coordinate with other NSF offices and directorates as well as with other federal agencies to share scientific expertise and further NSF's mission.
- Represent their program, division, and NSF overall within the agency, to other agencies, and to the scientific community and the public.

Agency Highlight NSF program managers can be permanent agency staff or "rotators" – working scientists who take leave from their home institutions to serve for fixed terms as NSF program managers. Employing rotators alongside permanent agency staff helps the agency maintain close connections with the broader scientific community and brings up-to-date expertise to the agency on a continuous basis.

NATIONAL SCIENCE FOUNDATION (NSF)
Research Obligations at a Glance (in billions)



NSF obligated about $6.4 billion for basic and applied research in FY 2021: the 4th largest amount obligated among the 32 federal government agencies.



Source: GAO analysis of National Science Foundation data. | GAO-24-106297

Note: National Science Foundation, National Center for Science and Engineering Statistics, *Survey of Federal Funds for Research and Development: Fiscal Years 2020–2021*. NSF 22-323 (Alexandria, VA: 2022). NSF referred to these FY 2021 data as 'preliminary' in survey documentation because these data were updated in the subsequent volume of the survey. We refer to the FY 2021 data as 'estimates' throughout this appendix.

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Totals may not add up because of rounding.

National Aeronautics and Space Administration (NASA)

NASA's mission is to explore the unknown in air and space, innovate for the benefit of humanity, and inspire the world through discovery.

NASA pursues scientific discovery and exploration for the benefit of the United States and all of humanity. NASA seeks to discover the secrets of the universe, search for life elsewhere, and protect and improve life on Earth and in space.

NASA Research Components NASA consists of five mission directorates, with most of the basic and applied scientific research funded by the Science Mission Directorate. The other NASA mission directorates also fund some basic and applied research:

Science Mission Directorate is NASA's largest grant issuing mission directorate and conducts scientific exploration that is enabled by access to space. Primary areas of study include astrophysics, biological and physical sciences, earth science, and planetary science.

Aeronautics Research Mission Directorate seeks to serve the future needs of U.S. commercial aviation by conducting research and technology development, including areas such as high-speed commercial flight, ultra-efficient transport, and airspace safety.

Space Technology Mission Directorate seeks to develop transformative crosscutting technologies to enhance the capabilities and reduce the cost of NASA missions. Research includes developing technologies for lunar exploration.

Space Operations Mission Directorate funds basic and applied scientific research through its Human Research Program.

Exploration Systems Development Mission Directorate established the Moon to Mars Program Office to focus on hardware development, mission integration, and risk management functions for programs critical to the agency's exploration approach.

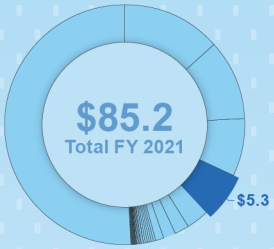
NASA Program Managers Approximately 125 program managers (known as program officers) in the Science Mission Directorate:

- Manage all aspects of the proposal cycle, often in collaboration with one or more colleagues from the division who help with specific portions of the portfolio.
- Manage the selection process (planning the solicitation, evaluation, selection, notification, reconsideration, and award).
- Develop recommendations regarding the selection of projects for funding.
- Advise NASA senior management on scientific matters.
- Receive and evaluate reports submitted by funded researchers, including scientific and financial reports.

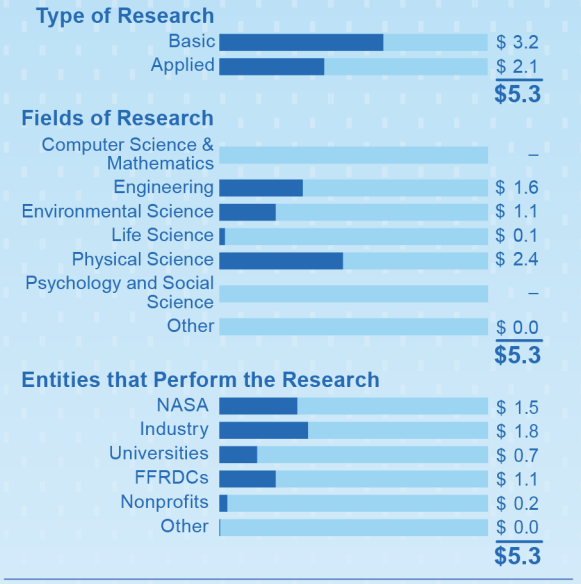
Agency Highlight At NASA, scientific program management is a job function rather than a staff position. Program managers are usually NASA program scientists whose additional responsibilities include ensuring the scientific success of NASA missions and advising senior leadership on scientific matters.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)

Research Obligations at a Glance (in billions)



NASA obligated about $5.3 billion for basic and applied research in FY 2021: the 5th largest amount obligated among the 32 federal government agencies.



Source: GAO analysis of National Science Foundation data. | GAO-24-106297

Note: National Science Foundation, National Center for Science and Engineering Statistics, *Survey of Federal Funds for Research and Development: Fiscal Years 2020–2021*. NSF 22-323 (Alexandria, VA: 2022). NSF referred to these FY 2021 data as 'preliminary' in survey documentation because these data were updated in the subsequent volume of the survey. We refer to the FY 2021 data as 'estimates' throughout this appendix.

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Veterans Affairs (VA)

VA's mission is to care for those who have served in the nation's military and their families, caregivers, and survivors.

VA conducts research to improve veterans' health and well-being; apply scientific knowledge to develop effective individualized care solutions; attract, train, and retain the highest-caliber investigators and nurture their development as leaders in their fields; and assure a culture of professionalism, collaboration, accountability, and the highest regard for research volunteers' safety and privacy.

VA Research Components VA conducts research through the Veterans Health Administration's Office of Research and Development. The Office of Research and Development has four research services:

Biomedical Laboratory Research and Development Service conducts preclinical research to better understand diseases at the molecular, genomic, and physiological levels.

Clinical Science Research and Development Service focuses on clinical trials to study new treatments, compare existing therapies, and improve clinical practice and care.

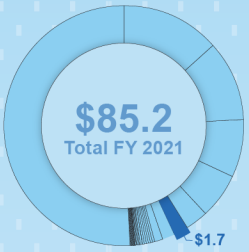
Health Services Research and Development Service supports research to improve the delivery of health care to veterans.

Rehabilitation Research and Development Service conducts research on innovations that could restore disabled veterans to their greatest possible functional capacity in their personal lives and workplaces.

VA Program Managers Approximately 30 program managers (known within VA as health science officers, scientific program managers, and portfolio managers):

- Develop research goals, priorities, and timelines for their research service.
- Collaborate with researchers, organizations, and universities to develop research projects that further VA's mission and objectives.
- Manage the scientific review of incoming applications, including recruiting a diverse pool of subject matter experts to serve as reviewers.
- Review progress reports from awarded projects to assess the need for project modifications, and advise funded researchers as needed based on these reports.
- Mentor VA researchers and help them prepare scientific proposals for funding. This includes providing advice on design to ensure the proposals meet regulations and requirements and offering guidance on the intramural merit review process, career development programs, and other intramural funding opportunities.
- Communicate with agency leadership and the broader research community about the status of VA programs.
- Participate in public outreach, including to community-based research groups, health care scientists and providers, and medical school representatives.

VETERANS AFFAIRS (VA)
Research Obligations at a Glance (in billions)



VA obligated about $1.7 billion for basic and applied research in FY 2021: the 7th largest amount obligated among the 32 federal government agencies.

Type of Research

Basic	$ 0.7
Applied	$ 1.0
	$1.7

Fields of Research

Computer Science & Mathematics	–
Engineering	$ 0.1
Environmental Science	–
Life Science	$ 1.3
Physical Science	–
Psychology and Social Science	$ 0.2
Other	$ 0.1
	$1.7

Entities that Perform the Research

VA	$ 1.6
Industry	–
Universities	–
FFRDCs	$ 0.1
Nonprofits	–
Other	–
	$1.7

Source: GAO analysis of National Science Foundation data. | GAO-24-106297

Note: National Science Foundation, National Center for Science and Engineering Statistics, *Survey of Federal Funds for Research and Development: Fiscal Years 2020–2021*. NSF 22-323 (Alexandria, VA: 2022). NSF referred to these FY 2021 data as 'preliminary' in survey documentation because these data were updated in the subsequent volume of the survey. We refer to the FY 2021 data as 'estimates' throughout this appendix.

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Agency Highlight Most VA-funded basic and applied research is intramural (performed by VA-employed researchers). Intramural researchers compete for agency funding through a peer review process. VA researchers typically collaborate with academic institutions, and most are also faculty members at academic institutions. This model helps ensure that VA's research is grounded in the experience of clinicians working directly with veterans in VA medical centers.

Environmental Protection Agency (EPA)

EPA's mission is to protect human health and the environment.

EPA conducts research on environmental issues at its laboratories located across the U.S. EPA also provides grants to environmental programs, nonprofits, academic institutions, and others to conduct scientific studies.

EPA Research Components The Office of Research and Development (ORD) is the primary manager of research at EPA. A large portion of the EPA's Science and Technology appropriations account funds research activities managed by ORD, including research grants.

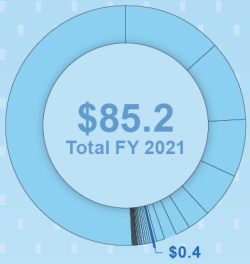
ORD's research is organized around the following six transdisciplinary national research programs that are aligned with EPA's strategic goals:

- **Air, Climate, and Energy** lays the foundation for research that improves air quality, addresses the causes and consequences of climate change, and protects public health and the environment.
- **Chemical Safety for Sustainability** focuses on addressing the environmental and health challenge of the lack of sufficient information to make informed, risk-based decisions about chemicals.
- **Health and Environmental Risk Assessment** *d*evelops and applies research to characterize the impacts on human and ecological systems, whether from exposure to single, complex, or multiple physical, chemical, or biological stressors.
- **Homeland Security** addresses science gaps related to oil spill response, protection of water systems, and cleanup of wide areas contaminated with high-priority chemical, biological, radiological, and nuclear agents of high priority to homeland security.
- **Safe and Sustainable Water Resources** provides research and scientific analyses to protect people's health and livelihood while restoring and maintaining watersheds and aquatic ecosystems.
- **Sustainable and Healthy Communities** *t*akes a systems approach to integrating data from public health and other areas of science and engineering to support EPA priorities and empower communities to make scientifically informed decisions.

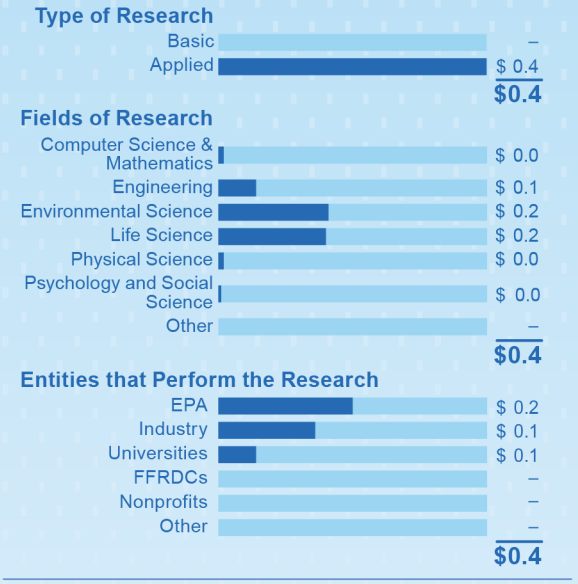
EPA Program Managers About 20 program managers (known within EPA as project officers for assistance agreements):

- Help define and communicate research needs in program areas, including preparing background documents for scientific programs and leading teams in writing funding opportunity announcements.
- Manage parts of the proposal review process that do not involve external peer reviewers.
- Provide scientific analysis to agency leadership to help them identify research gaps and priorities for the agency.
- Monitor awarded projects to ensure researchers perform the work for which they received awards and comply with agency policies and procedures.

ENVIRONMENTAL PROTECTION AGENCY (EPA) Research Obligations at a Glance (in billions)



EPA obligated about $0.4 billion for applied research in FY 2021: the 11th largest amount obligated among the 32 federal government agencies.



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Agency Highlight ORD conducts research to support the agency's decision-making and meet the emerging needs of its stakeholders, including state, tribal, and community partners. ORD sets strategic priorities for EPA's scientific research through a process of creating 4-year Strategic Research Action Plans for each research program. Senior project officers provide input on the Strategic Research Action Plans.

Appendix II: GAO Contact and Staff Acknowledgments

GAO Contact

Candice N. Wright, (202) 512-6888 or WrightC@gao.gov

Staff Acknowledgments

In addition to the individual named above, Tind Shepper Ryen (Assistant Director), Arvin Wu (Analyst-in-Charge), Karen (Maggie) Bryson, Virginia Chanley, Jehan Chase, Deborah Cohen, Louise Fickel, Minda Nicolas, Mazarine-Claire Penzin, Joe Rando, and Kiley Wilson made key contributions to this report.

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Page 37: Dept. of Health and Human Services (HHS seal); Lydia Polimeni. National Institutes of Health (National Institutes of Health building).

Page 38: U.S. Dept. of Energy (seal); U.S. Dept. of Energy (Dept. of Energy facility).

Page 39: Dept. of Defense (seal), Dept. of Defense (Pentagon).

Page 40: NSF (seal); NSF (NSF building).

Page 41: NASA (seal), NASA (NASA facility).

Page 42: Dept. of Veterans Affairs (seal); Dept. of Veterans Affairs (Veterans Affairs hospital).

Page 43: EPA (seal); EPA (EPA building).

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