# Chapter 1
## Management's Discussion and Analysis

# Agency Overview

## Mission and Vision

This past year, 2020, marked 75 years since Vannevar Bush delivered the seminal report to the President, *Science—The Endless Frontier,* that called for the creation of a new government organization devoted to advancing fundamental research. In 1950, that vision led to the establishment of a new federal agency, the National Science Foundation (NSF), with a challenging and inspiring mission, "to promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense…"[1] This mission continues to guide the agency today, as NSF remains the only federal agency dedicated to advancing basic research and education across the spectrum of science, technology, engineering, and mathematics (STEM) fields and disciplines.

### NSF's newest solar telescope produces first images

In January of 2020, NSF unveiled the first images from the Daniel K. Inouye Solar Telescope (DKIST), the largest solar telescope in the world and a state-of-the-art observatory that will generate more data on the sun in the next five years than scientists have collected so far in the history of solar observation. Positioned at the summit of Haleakala on the Hawaiian island of Maui, DKIST is designed to provide un-precedented insight into the sun's magnetic field. By better understanding the magnetic field, scientists will be able to predict more accurately "space weather" like solar wind and magnetically charged eruptions of plasma from sun that can interfere with satellites and ground-based communications systems. Combined with the space-based Parker Solar Probe and Solar Orbiter missions, DKIST is at the forefront of a new era of breakthroughs in understanding our sun.
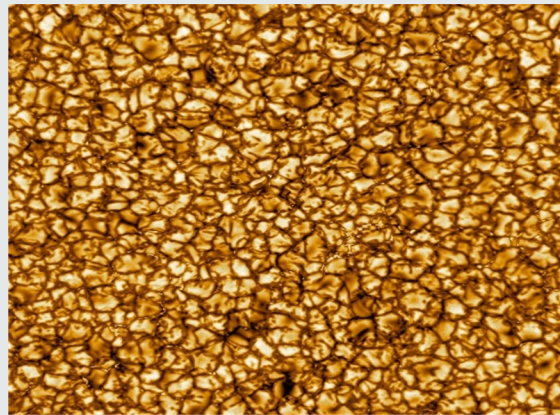
DKIST has produced this image that shows a pattern of turbulent, "boiling" gas that covers the entire sun. *Credit: NSO/AURA/NSF.*

In no year has the wisdom of Dr. Bush's vision and the importance of NSF to the Nation been as evident as it has this past year. Not only did NSF fund over 500 projects under the CARES Act (Coronavirus Aid, Relief, and Economic Security Act, P.L. 116-136) that specifically focused on the coronavirus (COVID-19) pandemic, the larger response of the Nation's researchers to this unprecedented challenge was possible only because of the underlying strengths of the United States (U.S.) science and engineering enterprise. These strengths enabled researchers to reimagine their work, forge new collaborations, and capitalize on technological capabilities that were being advanced and often invented in real time. These strengths are the direct result of 70 years of investing in "the progress of science," an investment that has yielded transformative breakthroughs and led to the creation of critical industries, tools, and products that enhance and engage every aspect of our lives. Just as these advances have led to the Internet, smartphones, 3D printing, spectrum auctions, Magnetic Resonance Imaging, an algorithm for kidney exchanges, weather radar, and the first image of a black hole, so too have they led to discoveries and insights that are vital to addressing the scourge brought by COVID-19.

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[1] *National Science Foundation Act of 1950* (P.L. 81–507)

In fiscal year (FY) 2020, NSF's research priorities were guided by Big Ideas[2] and the Industries of the Future, the set of cutting-edge goals to enable rapid advances across such areas as artificial intelligence, quantum computing, and big data. NSF's Expeditions in Computing program is investing in research to combine artificial intelligence and machine learning with social sciences and other disciplines to simulate epidemics and how people and communities respond, ultimately giving public health officials, policymakers, and community leaders new insights on how to prepare for and respond to epidemics. Also, in FY 2020, NSF-funded nanotechnology researchers helped build better technologies and materials that touch nearly all aspects of daily life, from medical imaging to protective gear for first responders. Other research advanced improvements in agricultural production to boost long-term crop yields, environmental sustainability, and profitability for farmers; minimally invasive photodynamic treatments for cancer; and robust and resilient systems to protect critical infrastructure, such as power grids, from malicious actors or natural disasters. NSF also supported scientists unlocking mysteries in Earth's ocean environments using large research vessels and small autonomous submersibles.

### *Tiny optical cavities could advance quantum networks*

Engineers have reached a new milestone for Quantum Information Science and the quest to create a quantum internet. The internet as we know it today is built on familiar technology like high-power microprocessors that power computation and networking infrastructure that is the backbone of connectivity, but scientists are still designing counterparts for the future of quantum computing. Funded by NSF under the Quantum Leap Big Idea, researchers have answered an important question about how quantum information can be sent and received through a quantum internet. Scientists can encode information in the quantum properties of individual atoms, which can be transmitted to other quantum computers. But how to "read" that information when it is received has been an open question until now. The researchers sculpted microscopic cavities in tiny pieces of crystal capable of holding atoms encoded with quantum information and sensing the atom's quantum properties. Just as technology like floppy disks kickstarted the digital age in 1960s, quantum breakthroughs like this are enabling leaps forward in the Industries of the Future.



NSF-funded researchers are working to create the building blocks of a quantum network. *Credit: The Opte Project/Wikimedia (CC BY 2.5).*

Many of FY 2020's accomplishments emphasize how important partnerships are to spurring innovation and discovery. In coordination with the White House, Congress, and three other agencies, NSF established seven National Artificial Intelligence (AI) Research Institutes, five fully funded by NSF and two fully funded by the U.S. Department of Agriculture National Institute of Food and Agriculture. The AI Institutes will catalyze transformational advances across many sectors of our Nation's economy, from extreme weather preparedness to Kindergarten to Grade 12 (K-12) education, all the while training the next generation of AI innovators and users.[3] Throughout FY 2020, NSF-funded researchers worked in collaboration with scientists from 20 countries on the Multidisciplinary Drifting Observatory for the Study of Arctic Climate

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[2] NSF's Big Ideas: https://www.nsf.gov/news/special_reports/big_ideas
[3] AI Institutes: https://www.nsf.gov/news/special_reports/announcements/082620.jsp

(MOSAiC[4]) expedition, an ambitious international Arctic field mission. Their observations will improve our understanding of the current state and likely future trajectory of the Arctic. NSF also is partnering with the National Aeronautics and Space Administration (NASA) to look at new approaches to expand the understanding of space weather and its impact on the Earth, and to improve the ability to forecast future events.

NSF's sustained investments in research facilities foster collaboration and provide sophisticated platforms for research at the cutting-edge. These investments provide the infrastructure needed to advance discovery, learning, and exploration, including ships, aircraft and autonomous airborne platforms, ground-based telescopes, and other infrastructure and state-of-the-art tools to sustain the Nation's scientific enterprise. NSF also supports research stations in the Arctic and Antarctic. In January 2020, NSF unveiled the first images from the Daniel K. Inouye Solar Telescope (DKIST), the largest solar telescope in the world. In the midst of the COVID-19 pandemic, researchers across the country turned to NSF-funded high-performance computing (HPC) resources to better understand COVID-19. For example, the NSF-funded Frontera supercomputer, the most powerful machine deployed on an academic campus in the world, was used to study how the virus interacts with the human body on an atomic level, as well as how it spreads from person-to-person. Researchers are developing detailed models of the virus's structure and transmission that rely on complex simulations involving large amounts of data. Together with the White House, IBM, and U.S. Department of Energy, NSF co-established the COVID-19 HPC Consortium to allow researchers from around the world to access HPC resources. The Foundation's long-term commitment to steady advancements and upgrades to research facilities enables this kind of ground-breaking research.

Other programs, such as NSF's Innovation Corps™, help researchers extend their focus beyond the university laboratory and translate a promising idea from the laboratory to the marketplace. The Small Business Innovation Research (SBIR) program helps startups and small businesses transform their ideas into marketable products and services by focusing on high-risk, high-impact technologies.

NSF's sustained investment in basic research generates a steady stream of new ideas and techniques that, together with a well-educated STEM workforce, foster a world-class research enterprise. NSF programs support STEM education and training that attract talented scientists and engineers from every corner of our Nation—from remote rural areas to the largest urban centers. The NSF Inclusion Across the Nation of Communities of Learners of Underrepresented Discoverers in Engineering and Science (INCLUDES) Program, through its emphasis on broadening participation, exemplifies the high-priority NSF places on increasing the participation of underrepresented groups in the STEM workforce. NSF also supports a strong STEM workforce through the Graduate Research Fellowship Program (GRFP). Since 1952, NSF has funded approximately 62,000 Graduate Research Fellows, many of whom go on to become leaders in their chosen fields and make groundbreaking and important discoveries in STEM research. Over 450 Graduate Research Fellows have become members of the National Academies of Sciences, Engineering, and Mathematics; and 40 Fellows have been honored as Nobel laureates. NSF also has funded the research of 248 individuals who have gone on to win the Nobel Prize, along with 41 individuals who have gone on to win the ACM[5] A.M. Turing Award, often referred to as the "Nobel Prize of Computing." These investments in people are a critical means by which NSF achieves its mission; transformational breakthroughs are shaped by a wide range of perspectives.

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[4] Multidisciplinary Drifting Observatory for the Study of Arctic Climate (MOSAiC) https://mosaic-expedition.org/
[5] ACM: Association for Computing Machinery

NSF's vision is to ensure that the U.S. remains the global leader in research and innovation. NSF's core values of excellence, public service, learning, inclusion, collaboration, integrity, and transparency articulate the essential qualities that staff are encouraged to embody in support of the agency's mission and vision. These core values guide staff in making decisions, setting priorities, addressing challenges, managing tradeoffs, recruiting and developing personnel, and working together with awardee recipients. NSF's strategic plan for FY 2018 – 2022, *Building the Future: Investing in Discovery and Innovation*,[6] identifies three interrelated goals for achieving the agency's mission: (1) expand knowledge in science, engineering, and learning; (2) advance the capability of the Nation to meet current and future challenges; and (3) enhance NSF's performance of its mission.

Public investment in high-risk, foundational research fulfills the strategic vision for scientific progress that will shape the future of our Nation. NSF supports 24 percent of all federally-sponsored basic scientific research conducted by America's colleges and universities; and NSF's support increases to 57 percent when medical research supported by the National Institutes of Health is excluded.[7]
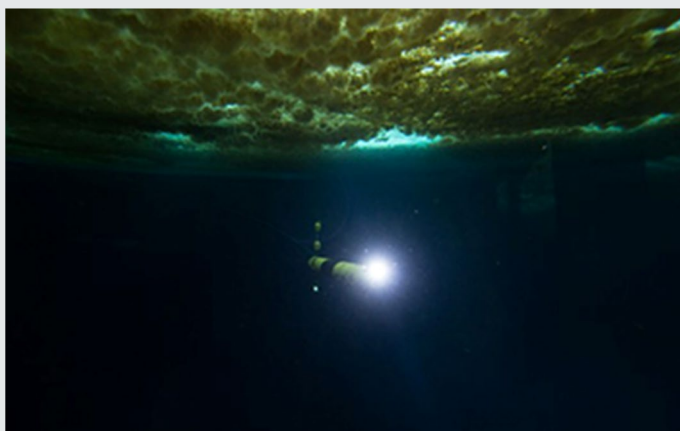


Scientists conduct first study beneath Antarctica's Thwaites Glacier.
*Credit: Georgia Tech University.*

*Robotic underwater vehicle snaps first images of seafloor beneath Antarctica's Thwaites Glacier*

Antarctica is one of the most extreme environments on the planet. Despite the harsh environment and forbidding conditions, researchers funded by NSF are probing Antarctica's secrets above and below the ice. Using an underwater robot called Icefin, researchers with the International Thwaites Glacier Collaboration were able to study the ocean floor beneath the Thwaites Glacier—a fast-moving glacier about the size of Florida flowing into the Pine Island Bay off of West Antarctica. By diving beneath the waves, researchers are hoping to better understand the conditions in the area around the glacier and the changes taking place as it flows into the sea. The information is critical to our understanding of oceanography, sea-levels, and polar phenomena.
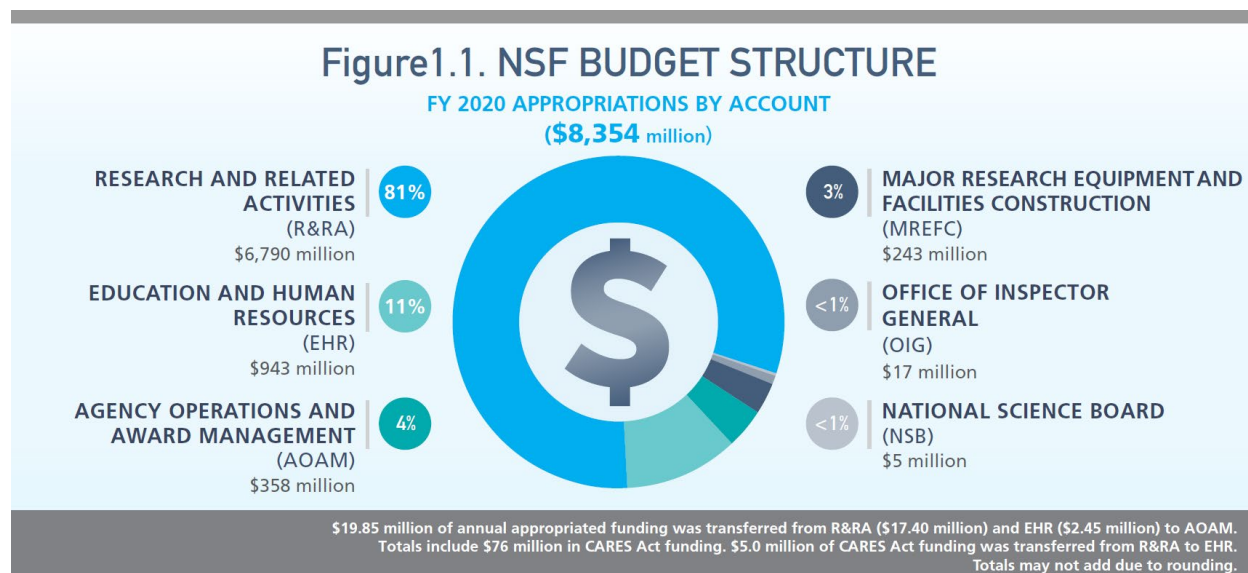
## NSF by the Numbers

NSF is funded primarily through congressional appropriations that are provided to six accounts: Research and Related Activities (R&RA), Education and Human Resources (EHR), Major Research Equipment and Facilities Construction (MREFC), Agency Operations and Award Management (AOAM), the National Science Board (NSB), and the Office of Inspector General (OIG). Appropriations in these six accounts in FY 2020 totaled $8,354 million[8], an increase of approximately 3 percent over the FY 2019 appropriations level of $8,075 million. R&RA, EHR, and MREFC appropriations fund the agency's programmatic activities

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[6] NSF Strategic Plan FY 2018 – 2022: https://www.nsf.gov/pubs/2018/nsf18045/nsf18045.pdf

[7] National Center for Science and Engineering Statistics Survey of Federal Funds for Research and Development Fiscal Years 2018–2019: https://ncsesdata.nsf.gov/fedfunds/2018/index.html

[8] Amount shown is NSF's FY 2020 discretionary appropriations. This amount does not include Donations and H-1B Nonimmigrant Petitioner Receipts. These amounts are included in NSF's appropriations shown in the Statement of Budgetary Resources (SBR). The SBR is on page Financials-17 of this *Agency Financial Report (AFR)*.

and accounted for 95 percent of NSF's total appropriations in FY 2020. Figure 1.1 provides details on NSF's FY 2020 appropriations. Of this total for FY 2020, $76 million was provided as a supplemental appropriation under the CARES Act. This additional funding is included in the appropriations totals described here, and a separate section (*COVID-19 Activities*) provides details on this supplemental funding by account.

## Figure 1.1. NSF BUDGET STRUCTURE

### FY 2020 APPROPRIATIONS BY ACCOUNT ($8,354 million)

**RESEARCH AND RELATED ACTIVITIES (R&RA)** $6,790 million — 81%

**EDUCATION AND HUMAN RESOURCES (EHR)** $943 million — 11%

**AGENCY OPERATIONS AND AWARD MANAGEMENT (AOAM)** $358 million — 4%

**MAJOR RESEARCH EQUIPMENT AND FACILITIES CONSTRUCTION (MREFC)** $243 million — 3%

**OFFICE OF INSPECTOR GENERAL (OIG)** $17 million — <1%

**NATIONAL SCIENCE BOARD (NSB)** $5 million — <1%

$19.85 million of annual appropriated funding was transferred from R&RA ($17.40 million) and EHR ($2.45 million) to AOAM. Totals include $76 million in CARES Act funding. $5.0 million of CARES Act funding was transferred from R&RA to EHR. Totals may not add due to rounding.

- R&RA supports basic research and education activities in science and engineering, including high-risk and transformative research. This appropriation accounted for 81 percent of FY 2020 funding. The FY 2020 R&RA funding level of $6,790 million was $285 million higher than the FY 2019 appropriation of $6,505 million.

- EHR, which supports activities to develop a diverse and well-prepared U.S. STEM workforce and a scientifically literate citizenry, is NSF's second largest appropriation and is over 11 percent of the agency's budget. EHR's FY 2020 funding level of $943 million was $21 million above the FY 2019 EHR appropriation of $922 million.

- FY 2020 AOAM funding of $358 million supported NSF agency operations and award management activities through which NSF's science and engineering research and education programs are administered. AOAM was over 4 percent of NSF's total FY 2020 appropriations. AOAM increased by nearly $25 million from the FY 2019 level of $333 million.

- The MREFC appropriation supports the acquisition, construction, and commissioning of major and mid-scale infrastructure that provide unique capabilities at the frontiers of science and engineering. This account was about 3 percent of the agency's total appropriations in FY 2020. The FY 2020 MREFC funding level of $243 million was $53 million below the prior-year appropriation of $296 million.

- Separate appropriations support the activities of the OIG and the NSB; each accounted for less than 1 percent of NSF's total FY 2020 appropriations. The FY 2020 OIG appropriation of $16.5 million increased approximately $1 million over the FY 2019 appropriation. The NSB received an appropriation of $4.5 million in FY 2020, $130,000 higher than the previous year's funding level.

Approximately 30,000 members of the science and engineering community participated in the merit review process as panelists and proposal reviewers.[9] Awards were made to almost 1,900 institutions located in all 50 states, the District of Columbia, and three U.S. territories. These institutions employ many of America's leading scientists, engineers, and educators; and they train the leading innovators of tomorrow. In FY 2020, about 313,000 people were directly involved in NSF-funded programs and activities. Beyond these figures, NSF programs indirectly impact millions of people, reaching K-12 students and teachers, the general public, and researchers through activities including workshops; informal science activities such as museums, television, videos, and journals; outreach efforts; and dissemination of innovative instructional resources and teaching methods.

During FY 2020, NSF evaluated over 42,700 proposals through a competitive merit review process and made approximately 12,200 new competitive awards, mostly to academic institutions. In addition to these proposals, GRFP reviewed approximately 13,000 applications for fellowships. As shown in Figure 1.2, the Award Mechanisms chart, NSF's award funding was used primarily for financial assistance to carry out a public purpose through grants and cooperative agreements. Grants can be either standard awards, in which funding for the full duration of the project is awarded in a single fiscal year, or continuing awards, in which funding for a multi-year project is awarded in increments. Cooperative agreements are used when the project requires substantial agency involvement (such as research centers and multi-use facilities). Contracts are used to acquire products, services, and studies, such as program evaluations, required for NSF or other government use.
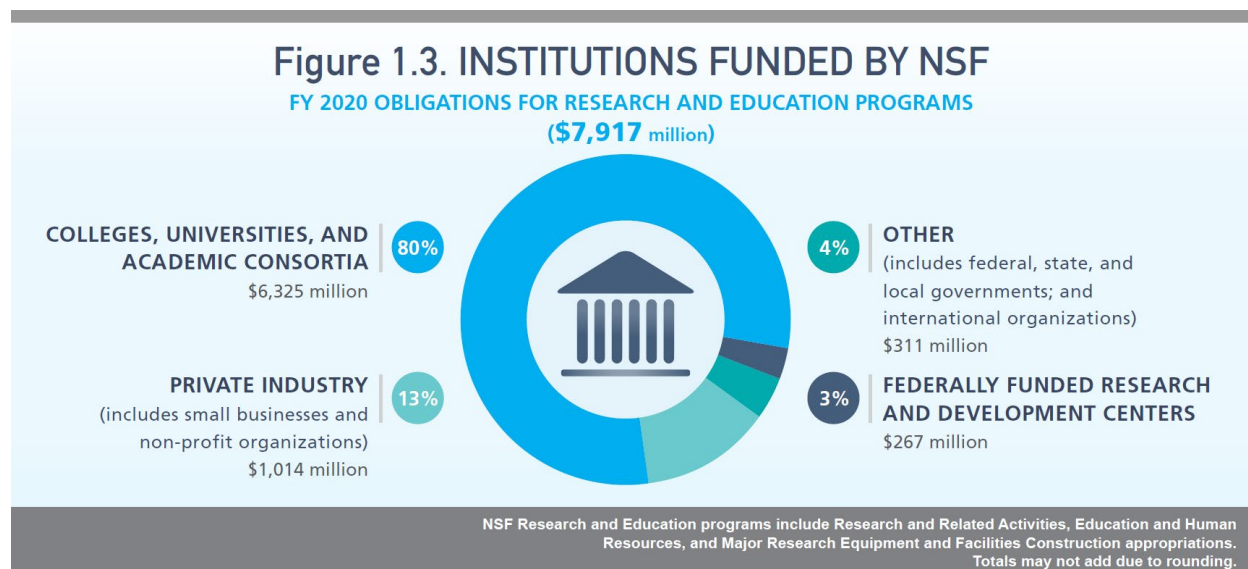


Figure 1.2. NSF AWARD MECHANISMS
FY 2020 OBLIGATIONS FOR RESEARCH AND EDUCATION PROGRAMS
($7,917 million)
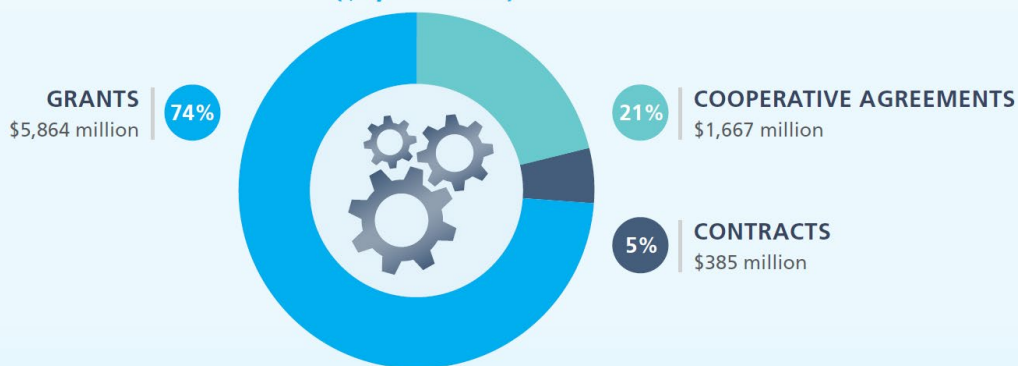
GRANTS — $5,864 million — 74%
COOPERATIVE AGREEMENTS — 21% — $1,667 million
CONTRACTS — 5% — $385 million

NSF Research and Education programs include Research and Related Activities, Education and Human Resources, and Major Research Equipment and Facilities Construction appropriations. Totals may not add due to rounding.

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[9] For more information about NSF's merit review process, see https://www.nsf.gov/bfa/dias/policy/merit_review/ and *NSF's Merit Review Process, FY 2018 Digest* (NSB-2020-13) at https://www.nsf.gov/nsb/publications/2020/nsb202013.pdf

As shown in Figure 1.3, the Institutions Funded chart, 80 percent of support for research and education programs ($6,325 million) was provided to 822 different colleges, universities, and academic consortia. Private industry, including small businesses and non-profit organizations, accounted for 13 percent ($1,014 million), and support to Federally Funded Research and Development Centers accounted for 3 percent, or $267 million. Other recipients (federal, state, and local governments; and international organizations) received 4 percent ($311 million) of support for research and education programs.



Figure 1.3. INSTITUTIONS FUNDED BY NSF
FY 2020 OBLIGATIONS FOR RESEARCH AND EDUCATION PROGRAMS
($7,917 million)

COLLEGES, UNIVERSITIES, AND ACADEMIC CONSORTIA — 80% — $6,325 million

PRIVATE INDUSTRY (includes small businesses and non-profit organizations) — 13% — $1,014 million

OTHER (includes federal, state, and local governments; and international organizations) — 4% — $311 million

FEDERALLY FUNDED RESEARCH AND DEVELOPMENT CENTERS — 3% — $267 million

NSF Research and Education programs include Research and Related Activities, Education and Human Resources, and Major Research Equipment and Facilities Construction appropriations. Totals may not add due to rounding.

## COVID-19 Activities

NSF worked closely with the scientific research community to bolster the national response to the COVID-19 pandemic and employed several research funding mechanisms, notably Rapid Response Research (RAPID), a fast-tracked grant process designed to accelerate critical discovery. NSF-funded research related to the pandemic aligned with the following research areas:

- Improving our understanding of the coronavirus.
- Developing a predictive understanding of the spread of the virus.
- Enabling approaches that mitigate the negative impacts of COVID-19 on public health, society, and the economy.

As part of the CARES Act, NSF received $76 million in funding, of which $75 million supported a wide range of research to help the country "prevent, prepare for, and respond to coronavirus."[10] In addition, NSF drew from its FY 2020 base appropriations and other available funds to support research related to COVID-19. NSF's COVID-19 activities funded 1,172 awards to nearly 2,250 principal investigators in 48 states and the District of Columbia. Table 1.1 shows the FY 2020 obligations related to COVID-19 activities.

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[10] Coronavirus Aid, Relief, and Economic Security Act, P.L. 116-136: https://www.congress.gov/116/plaws/publ136/PLAW-116publ136.pdf

**Table 1.1: FY 2020 COVID-19 Activity Awards and Obligations**
(Dollars in Millions)

|  | CARES Act | All COVID-19 |
|---|---|---|
| Number of Awards | 527 | 1,172 |
| FY 2020 Obligations (Total) | $76.0 | $197.5 |
| *R&RA* | *$70.0* | *$178.5* |
| *EHR[1]* | *$5.0* | *$16.7* |
| *AOAM* | *$1.0* | *$1.0* |
| *Other funding* | - | *$1.3* |

[1]NSF used transfer authority provided in P.L. 116-93, to transfer $5.0 million of R&RA CARES Act funding to the EHR budget account.

NSF's awardee institutions were impacted by the COVID-19 pandemic. Currently, the extent to which the pandemic impacted awards is being determined on an award-by-award basis. In the early months of the pandemic, NSF implemented time-limited administrative relief flexibilities applicable to NSF proposers and awardees affected by the loss of operational capacity and increased costs due to the COVID-19 pandemic in accordance with the Office of Management and Budget (OMB) guidance.[11] NSF Program and Grants Officers are responsible for determining how best to support research objectives for each award and are positioned to provide adjustments and flexibilities based on each situation. Flexibilities include adjustments to proposal deadlines, approval of progress reports, and modifications to project scope; the federal time-limited flexibilities mentioned above were applicable to areas such as salary support and deadlines for single audit submissions. While all NSF-funded major facilities construction projects have a contingency built in, the contingency budget is set based on known risks in control of a project. The situation with the pandemic extends beyond the realm of a foreseeable risk that a project could control.



**To better understand COVID-19 and how to stop it, researchers are increasingly turning to some of the most powerful and uniquely capable computing facilities in the world like the NSF-funded Frontera supercomputer located at The University of Texas at Austin. *Credit: Texas Advanced Computing Center.***

***Computing consortium takes on COVID-19***

For more than four decades, NSF has been at the forefront of advanced computing capabilities that underpin U.S. leadership in research and innovation. Now, NSF-supported computing systems are an essential element of the COVID-19 High Performance Computing (HPC) Consortium, which is enhancing access to HPC resources to support global health efforts in the face of an ongoing pandemic. The HPC Consortium is a unique public-private partnership—spearheaded by the White House Office of Science and Technology Policy, IBM, U.S. Department of Energy and NSF—that gives researchers working to understand the COVID-19 virus access to powerful computational platforms that can enable major breakthroughs. Through data analytics, machine learning, artificial intelligence, and other advanced computing capabilities, researchers are modeling COVID-19 transmission, simulating the atomic structure of viruses, and forging new paths for fighting the disease.

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[11] OMB M-20-17: https://www.whitehouse.gov/wp-content/uploads/2020/03/M-20-17.pdf; M-20-26: https://www.whitehouse.gov/wp-content/uploads/2020/06/M-20-26.pdf

Costs and delays for construction project completion will not be known until the lengths of project suspensions and the additional costs and time required to restart construction are better known.

With 100 percent of NSF employees telework-eligible prior to the start of the pandemic, staff continued to fulfill NSF's mission after transitioning into full-time telework in the spring. AOAM funding ($1 million) secured ongoing continuity of operations during the COVID-19 response period, including costs stemming from changes to NSF agency operations in a virtual working environment.

In this *AFR*, NSF-funded research awards are highlighted, but this represents just a snapshot of the essential work NSF funded through the CARES Act and its regular FY 2020 appropriations. The COVID-19 research grants awarded through NSF are available on the NSF.gov website.[12]

**RAPID award to study COVID-19 transmission through air and water**

The COVID-19 pandemic has raised countless questions about the disease itself and how it spreads through the environment. To help answer those questions, provide the best information to public health officials, and find new ways to stop the spread of the disease, NSF activated its Rapid Response Research funding mechanism, known as RAPID. These awards streamline funding for scientists who need to act fast to gather information and develop new technology that can make a difference in a crisis. One of those RAPID awards went to study how the coronavirus that causes COVID-19 travels through the air, wastewater, and other environments. A key element of this work is designing sensor networks that can monitor wastewater for evidence of the virus that appears before symptoms and hospitalizations, giving communities and public health officials the information they need to help isolate occurrences of the virus and limit its spread.
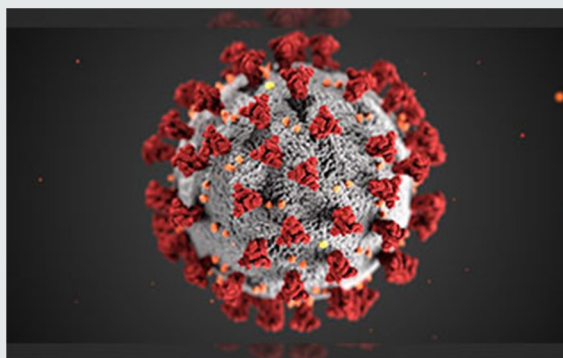


**This image shows SARS-CoV-2, the virus that causes COVID-19. Credit: Alissa Eckert, MS; Dan Higgins, MAMS, CDC.**

## Organizational Structure

NSF is an independent federal agency headed by a Director who is appointed by the President and confirmed by the U.S. Senate.[13] As shown in Figure 1.4, NSF's organizational structure aligns with the major fields of science and engineering.[14]

The NSF Director and the 24-member NSB jointly pursue the goals and functions of NSF, including the duty to "recommend and encourage the pursuit of national policies for the promotion of research and education in science and engineering."[15] The NSB identifies issues critical to NSF's future and helps chart the strategic direction of NSF's budget and programs. NSB members are appointed by the President and are prominent contributors to the STEM research and education community.[16] NSF's Director is a member *ex officio* of the Board. The Director and the other NSB members serve 6-year terms.

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[12] https://www.nsf.gov/awardsearch/simpleSearchResult?queryText=COVID+AND+RAPID
[13] The Director's biography: https://www.nsf.gov/staff/staff_bio.jsp?lan=spanchan&from_org=
[14] NSF's organization chart: https://www.nsf.gov/staff/organizational_chart.pdf
[15] 42 U.S. Code 1862(d): https://www.law.cornell.edu/uscode/text/42/1862
[16] NSB members during FY 2020 are shown in Appendix 9 of this *AFR*

Figure 1.4
**NSF FY 2020 Organization Chart**
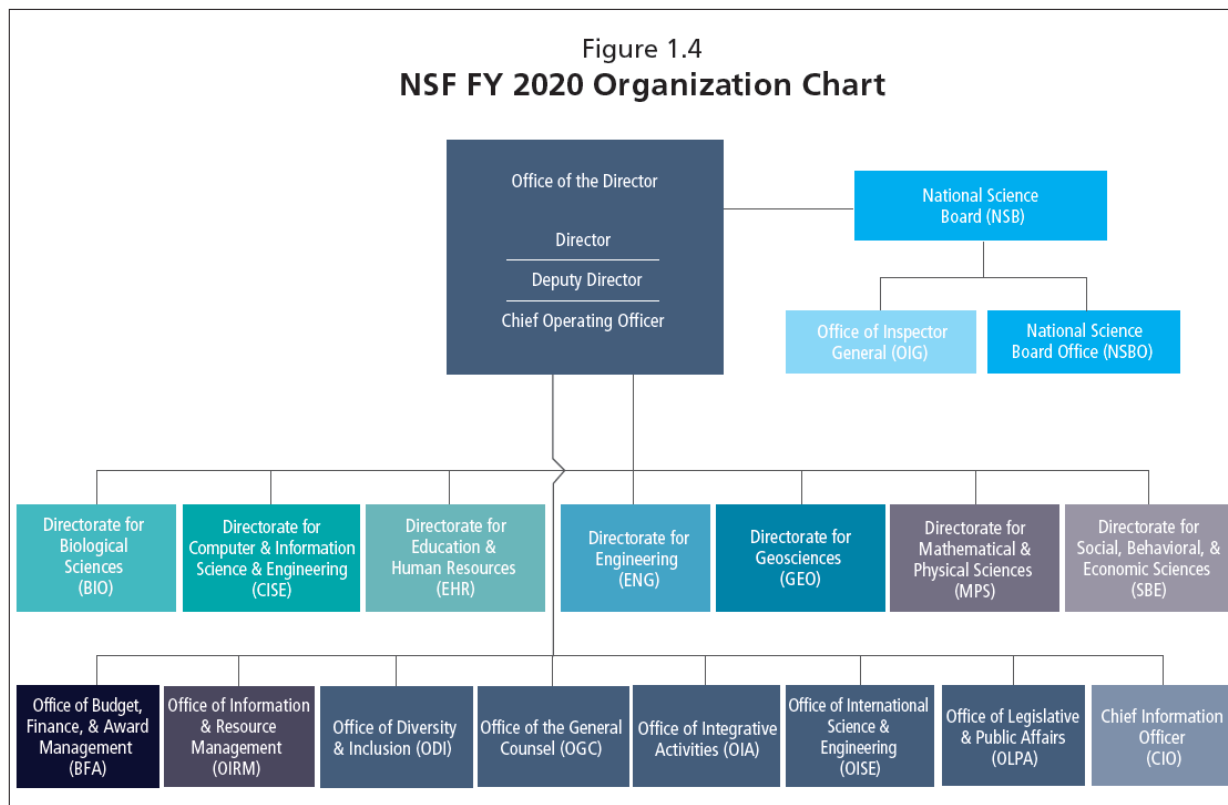
The NSF workforce included 1,421 federal employees in FY 2020.[17] In FY 2020, NSF and the American Federation of Government Employees Local 3403 signed a new collective bargaining agreement for approximately 1,000 NSF bargaining-unit employees. The last agreement was signed in 1982.

NSF regularly recruits scientists, engineers, and educators through the Intergovernmental Personnel Act (IPA) who work at NSF for up to 4 years. These "rotators" bring fresh perspectives from across the country and across all fields of science supported by NSF, helping explore new directions for research in science, engineering, and education, including emerging interdisciplinary fields. On returning to their home institutions and across academia, rotators bring knowledge of NSF programming and leading research from a national perspective. As of September 30, 2020, there were 177 temporary appointments under the IPA program.

In addition to the Foundation's headquarters in Alexandria, Virginia, NSF maintains an office in Christchurch, New Zealand, to support the U.S. Antarctic Program (USAP); and the OIG has an office in Denver, Colorado.

## Management Challenges

In October 2019, the OIG identified six areas representing challenges for the agency for FY 2020: (1) Managing Major Multi-User Research Facilities, (2) Meeting *Digital Accountability and Transparency*

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[17] Full-time equivalents (FTEs) include the federal employee workforce for NSF, the NSB, the OIG, and U.S. Arctic Research Commission

*Act of 2014* (DATA Act)[18] Reporting Requirements, (3) Managing the *Intergovernmental Personnel Act (IPA)* Program, (4) Managing the Antarctic Infrastructure Modernization for Science (AIMS) Project, (5) Encouraging the Responsible and Ethical Conduct of Research (RECR), and (6) Mitigating Threats Posed by Foreign Government Talent Recruitment Programs.[19] NSF activities relating to several of the Management Challenges were adjusted or reprioritized due to COVID-19 pandemic response actions. Nonetheless, progress on addressing the FY 2020 Management Challenges remained a priority for NSF and notable actions were taken in response to these challenges.

Management's report on the significant activities undertaken in FY 2020 to address the challenges is in *Appendix 2B: Management Challenges—NSF's Response* of this *AFR*. The report also discusses activities planned for FY 2021 and beyond. The following list summarizes some of the agency's significant actions and planned next steps to address the challenges.



The Institute for Student-AI Teaming aims to develop ground-breaking AI that helps both students and teachers work and learn together. *Credit: Phonlamai Photo/Shutterstock.*

**AI in the classroom**

Enhancing educational outcomes for all students is a critical part of building a STEM-enabled workforce and bolstering science and technology leadership for future generations. The Institute for Student-AI Teaming is designing new approaches to AI in the classroom to boost educational outcomes, foster deeper student engagement, and foster long-term interest in STEM subjects—especially for students from communities underrepresented in STEM fields. Working in close partnership with a diverse community of K-12 educators, students, parents, and stakeholders, researchers will deploy AI Partners that can interact naturally with students and teachers to augment classroom activities. This will give students the guidance they need to learn effectively while ensuring that educators can focus on what they do best: inspiring and teaching students. By supporting the development of AI-enabled tools that can be deployed in classrooms across the nation—including classrooms that are underrepresented in STEM—NSF is helping ensure that students from every community can develop their STEM talents.

### *Managing Major Multi-user Research Facilities*

NSF understands the importance of its role in overseeing recipients' on-going management of major facilities and assuring successful performance. The agency also recognizes the importance of assessing prospective recipients' capabilities for managing major facilities prior to award. Over the past several years, NSF has greatly strengthened its oversight policies and procedures. This includes an annual Major Facilities Portfolio Risk Assessment to determine the necessary reviews and audits to be conducted by the Large Facilities Office (LFO) and Cooperative Support Branch (CSB) within the Office of Budget, Finance and Award Management (BFA). In close cooperation with NSF program offices, LFO and CSB conduct these reviews to safeguard NSF's significant, long-term investments in supporting the scientific endeavor. Importantly, in FY 2020, NSF continued to strengthen the established governance structure to help ensure consistent implementation of NSF's controls for major facilities oversight. Since 2017, NSF has been through three Government Accountability Office (GAO) reviews related to its oversight of projects funded

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[18] DATA Act (P.L. 113-101): https://www.gpo.gov/fdsys/pkg/PLAW-113publ101/pdf/PLAW-113publ101.pdf

[19] The Inspector General's Memorandum on Management Challenges for NSF in FY 2020 is in NSF's *FY 2019 Agency Financial Report,* Appendix 2A: https://www.nsf.gov/pubs/2020/nsf20002/pdf/08-chap3-appendices.pdf

from the MREFC account. NSF has implemented corrective action plans and demonstrated progress towards addressing recommendations from these reports. The April GAO 2020 report had no new recommendations.

NSF has taken significant FY 2020 actions in response to the Office of Inspector General's (OIG's) identified challenge to continue to manage inherent risk associated with previously highlighted OIG concerns including the need for strengthened controls identifying subrecipients, completing subrecipient risk assessments, properly charging expenditures, and ensuring NSF and recipient project management expertise. Such actions include: (1) requiring recipients to develop Segregation of Funding Plans for several large NSF projects; (2) formalizing a process, under cognizance of the Chief Officer for Research Facilities in the Office of the Director (O/D), for tracing open action items periodically; (3) revising the *Business Systems Review (BSR) Guide* to better align with the Uniform Guidance and address implementation of Segregation of Funding Plans; and (4) implementing corrective actions in response to OIG Report 18-2-005, *Audit of NSF's Oversight of Subrecipient Monitoring*.

Going forward, NSF plans to continue strengthening its oversight by: (1) revising the *Obligation and Allocation of Management Reserve* Standard Operating Guidance (SOG); (2) finalizing and posting for public comment the *BSR Guide* and new/updated sections of the *Major Facilities Guide*; (3) finalizing the *Major Facilities Oversight Reviews* SOG; (4) completing the major facilities portfolio workforce gap analysis; and (5) ongoing monitoring of the allocation of funds between awards using Segregation of Funding plans.

**Inspired by cheetahs, researchers build fastest soft robots yet**

From navigating forbidding terrain in search-and-rescue missions to rapidly sorting fragile products in a warehouse environment, 'soft robots' have transformative potential in applications and environments that require machine assistants to have flexibility, agility, and a gentle touch. With a grant from NSF, engineers have developed a new type of soft robot that moves more than three times faster than previous designs. Inspired by the way that cheetahs derive their record speed by flexing their spine between two 'bi-stable' positions, researchers created soft robots that are faster and capable of running up steep inclines that are challenges for existing models. The engineers are already working on the next generation of their high-performing model, envisioning how their breakthrough could pave the way for multi-functional soft robots that may one day assist humans in a variety of environments.
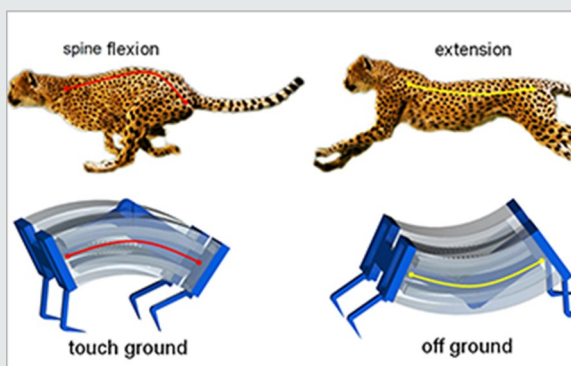


Inspired by the biomechanics of cheetahs, researchers have developed a new type of soft robot. *Credit: Jie Yin, North Carolina State University.*

### *Meeting Digital Accountability and Transparency Act of 2014 (DATA Act) Reporting Requirements*

The purpose of the DATA Act is to improve the quality and transparency of the Federal Government's award data. Lawmakers have directed the Department of the Treasury (Treasury) and the OMB to create government-wide standards for reporting spending data associated with federal awards. The law also requires that this data be channeled to a central, public database so that it can be easily accessed and tracked throughout an award's full lifespan—from a vote in Congress to its final disbursement.

NSF submits all data required by the DATA Act to Treasury. NSF is confident in the quality of the quarterly and monthly data submissions, and NSF's internal controls support the reliability and validity of the agency account-level and award-level data. The data that the OIG identified under this challenge as errors are not designated as "errors" in Treasury's DATA Act Information Model Schema (DAIMS) technical requirements, but are actually broker "warnings," which are previously disclosed as explainable differences. Since February, NSF has been in regular communication with OMB to further address these explainable differences. Examples of actions taken by NSF in FY 2020, include: (1) implemented a SharePoint tool to assist in the quarterly DATA Act submission processes by tracking Division Director assurances and Senior Accountable Officer certification; (2) incorporated lessons learned from feedback on data submissions to improve accuracy and efficiency; (3) updated DATA Act and Financial Assistance Broker System policies and procedures to reflect new requirements; (4) continued to work closely with OMB, Treasury, and intra-governmental groups to provide input into DATA Act technical guidance and policy; and (5) continued to collaborate with NSF OIG and GAO to support their audit responsibilities as well as to resolve any recommendations through implementing a corrective action plan.

Going forward, NSF will: (1) continue to provide feedback to OMB and Treasury on recommended guidance changes that will help clarify the nature of NSF's differences; (2) continue to work with the OIG to achieve a common understanding and resolution of this issue; (3) incorporate recommendations from the GAO audit into NSF's reporting processes and controls.

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**Seismic network from unlikely source**

How do you detect undersea earthquakes that can potentially cause devastating tsunamis? A team of NSF-funded geoscientists has found a way to use fiber optic communications cables at the bottom of the North Sea as a giant seismic network. While placing permanent seismic monitoring equipment on the seafloor would be prohibitively expensive, the fiber optic cables that already crisscross the ocean floor—carrying telecommunications signals between continents—are a ready-made solution. By sending a beam of light along the fiber optic cable, researchers detect tiny imperfections that reflect light back, which act as "waypoints" along the cable. When a seismic wave jostles the cable, the waypoints shift slightly, changing the way light in the cable is reflected and allowing researchers to take measurements of the seismic wave. By making creative use of existing infrastructure, researchers enhance disaster preparedness while opening up exciting new ways to study the Earth.



Researchers detected an earthquake by using fiber optic cable that connects a wind farm. *Credit: Riekelt Hakvoort/Shutterstock.com.*

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### *Managing the Intergovernmental Personnel Act (IPA) Program*

Through the IPA program, scientists, engineers, and educators rotate into the Foundation as temporary Program Directors, advisors, and leaders. Due to the nature of this program, the OIG identifies the IPA program as an area of inherent risk that NSF must continue to monitor and mitigate. In response, NSF has taken a proactive approach in the management of the IPA program to appropriately consider and mitigate inherent risks associated with its execution. NSF established a senior-level IPA Steering Committee that reports to the NSF Director and Chief Operating Officer (COO). The Committee ensures that NSF is best utilizing the IPA hiring authority and regularly reports on its oversight and stewardship of the IPA program, including costs associated with the program, to the Director and COO, OMB, and Congress. NSF engages in continuous improvement of its management of the IPA Program, addressing the management challenges identified by the OIG as well as other agency-identified risks and challenges. Through these

actions, NSF is confident it has reduced the inherent risk substantially, such that the residual risk is acceptable to the agency. Selected examples of steps taken by NSF in FY 2020 include: (1) delivered the IPA Program Annual Report to the Director of NSF, including annual data and trend analyses on various aspects related to the use of IPAs at NSF; (2) through NSF's Enterprise Risk Management program, identified IPA program objectives and associated risks as they pertain to NSF's mission; (3) monitored time spent on Independent Research/Development (IR/D) and provided quarterly data to senior managers for appropriate oversight of IPA time and travel; (4) submitted annual responses on the Justifications for Rotator Pay Exceeding the Senior Executive Service Pay Max to Congress; and (5) submitted the FY 2019 IPA Program Annual Report to O/D, which demonstrated that the 10 percent cost-share pilot has reduced/eliminated the gap between IPA reimbursements and federal employee salaries, and thus is not a major risk to the agency.

Going forward, NSF will: (1) continue the various reporting listed above to the NSF Director, NSF senior managers, and Congress; (2) continue to use the robust onboarding, training, knowledge transfer, and performance management systems that are in place to ensure that turnover of all employees and IPAs have minimal impact on operations; and (3) continue monitoring established IPA IR/D travel caps.

### *Managing the Antarctic Infrastructure Modernization for Science (AIMS) Project*
NSF funds and manages the USAP, which supports the U.S.'s research and national policy goals in the Antarctic. AIMS consists of six new structures being built to replace outdated buildings and consolidate key functions for more streamlined and efficient operations. The OIG identified the AIMS project as one that will require continued vigilance as it will stretch agency resources and may present additional challenges. While NSF agrees there are inherent risks associated with Antarctica's remote location, extreme environment, and the short period of time during which the continent is accessible, NSF has reduced risk levels to acceptable ranges through leadership commitments, dedication of staff and resources, corrective action planning, and monitoring implementation of plans. The global pandemic associated with COVID-19 has had impacts on USAP operations, resulting in significant changes to program and construction project plans. The global pandemic resulted in "excusable delays" for the contractor as well as additional government-directed delays in performance of work under the AIMS project, including placing the construction sites in a safe and stable configuration in March 2020 and bringing home deployed construction crews earlier than anticipated. In accordance with NSF policy, the magnitude of these impacts has required re-baselining the AIMS project, and the Office of Polar Programs is actively engaged with the contractor, BFA, and O/D for that purpose.

Among a number of milestones reached in FY 2020, NSF: (1) began on-site work on AIMS with approximately 16.5 percent of the project completed as of March 2020, when the pandemic began; (2) augmented the AIMS Integrated Project Team by adding a Project Controls Lead; (3) completed verification and acceptance of the AIMS Earned Value Management System (EVMS) in accordance with NSF policy; and (4) increased financial oversight of Construction in Progress reporting and construction invoicing.

Going forward NSF will: (1) continue monitoring and oversight of AIMS in accordance with established Internal Management and Project Execution Plans including external panel reviews and EVMS surveillance reviews for AIMS; (2) continue to assess COVID-19 impacts and evaluate options for minimizing negative impacts to AIMS cost and schedule; and (3) re-baseline AIMS and subject the revised cost, scope and schedule to external panel review, Facilities Readiness Panel Review, Director's Review Board Review, and NSB re-authorization of the Total Project Cost.

***Love basmati rice? Scientists have now sequenced its genome***

Rice is one of the most important staple crops worldwide, and now NSF-funded researchers have created the first complete, high-quality genome sequence for the iconic Basmati variety. By using nanopore sequencing technology, researchers assembled the complete genetic blueprint. The discovery sheds new light on how important crops adapt to different environments and how cultural preferences for certain qualities—like Basmati's fragrant aroma—can shape crop domestication. Breakthroughs like this are opening the door to new ways to enhance agricultural systems and food production around the world.

A new study offers clues to growing drought-tolerant and bacteria-resistant basmati rice. *Credit: Ajay Suresh via Wikimedia (CC-BY-2.0).*

### *Encouraging the Responsible and Ethical Conduct of Research (RECR)*

NSF views RECR holistically—not only as a responsibility to generate and disseminate knowledge with rigor and integrity, but also as a responsibility to conduct peer review with the highest ethical standards; diligently protect proprietary information and intellectual property from inappropriate disclosure; and treat students and colleagues fairly and with respect. This expectation is conveyed in the June 2020 update to the *Proposal and Awards Policies and Procedures Guide* (PAPPG) and on NSF's updated RECR web page.[20] NSF is working to understand and reduce the occurrence of irresponsible and unethical research conduct through three sets of actions: (1) characterizing the problem and identifying priorities through stakeholder engagement, complemented by data collection and analysis; (2) funding basic research into the underlying causes and potential solutions, including the effectiveness of different approaches to improve RECR; and (3) implementing change through policy and public engagement.

As stated in the Memorandum on Management Challenges for NSF in FY 2020, the OIG was encouraged by NSF's actions to strengthen training in the responsible conduct of research at NSF-funded institutions but also identified opportunities for improvement. Among the significant actions taken in FY 2020, NSF: (1) collected stakeholder input through participation in annual meetings of the Association for Practical and Professional Ethics; (2) continued to fund basic research to identify factors that are effective in the formation of ethical STEM researchers and approaches to developing those factors in the STEM fields supported by NSF; (3) provided intramural and extramural guidance, resources, and consultation for the inclusion of ethics considerations in citizen science, collaborative/team science, and international science; (4) in the 2020 PAPPG, provided a comprehensive definition of RECR and identified promising practices in RECR training; and (5) created a "Speak Up" campaign to raise awareness of resources available for personnel to address discrimination, bullying, harassment, stress and anxiety, physical safety, and violence in the workplace.

Going forward, NSF will: (1) continue to leverage NSF's leadership role as co-chair of the National Science and Technology Council (NSTC) Joint Committee on Research Environment (JCORE) Safe and Inclusive Research Environments subcommittee and the JCORE Rigor and Integrity in Research subcommittee to promote the coordination and development of RECR among federal agencies, including the National Institutes of Health; (2) establish a plan to assess the agency's harassment prevention efforts for university grantees, including methods to regularly monitor/evaluate policies and communication mechanisms;

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[20] RECR webpage: https://www.nsf.gov/od/recr.jsp

(3) collaborate with other federal agencies and the ethics community to strengthen the understanding and effectiveness of RECR training and community guidance; and (4) collaborate with other federal agencies to address harassment in a coordinated manner through active participation in the JCORE Safe and Inclusive Research Environment subcommittee and its ad hoc working groups.

### *Mitigating Threats Posed by Foreign Government Talent Recruitment Programs*

NSF seeks to maintain a vibrant science and engineering community for the benefit of the Nation. Participation in this community relies on individuals to uphold core principles and values such as openness, transparency, collaboration, and integrity. Unfortunately, this commitment to open scientific exchange and research today faces a challenge from the talent recruitment programs established by some foreign governments that deliberately disregard these core principles and incentivize participants to acquire U.S.-funded scientific research. These programs target scientists, engineers, and educators of all nationalities working or educated in the U.S. Given the risk talent recruitment programs pose for NSF, the OIG noted that NSF should continue to assess and refine its controls in this area and should work to ensure that it has sufficient staff and resources to respond to this challenge.

Over the past two years, NSF has taken steps to mitigate threats posed by foreign government talent recruitment programs. Among several significant actions taken in FY 2020, NSF: (1) created and filled the position of Chief of Research Security Strategy and Policy and established a Research Security Strategy and Policy Group; (2) issued clarifications to its proposal preparation requirements specified in the PAPPG to ensure senior personnel on proposals provide information on all sources of current and pending research support, foreign and domestic, as well as requiring all titled positions be identified in the biographical sketch; (3) standardized the format and streamlined the processes for disclosure as part of the revision to the PAPPG, with the new formats released in April 2020 and use of an NSF-approved format required for these sections of proposals submitted or due on or after October 5, 2020; (4) finalized a revised term and condition on foreign collaboration considerations for major facilities, effective October 5, 2020, for new awards and funding amendments on existing awards; (5) released mandatory training for all NSF personnel on science and security that includes modules on risks from foreign governments, NSF's policies on disclosure, and NSF's policies on staff participation in foreign government talent recruitment programs; and (6) engaged Congress through briefings focused on NSF's efforts to implement reasonable and necessary steps to ensure integrity of federally-funded research and protect against threats from foreign government talent recruitment programs.

Going forward, NSF will: (1) continue to serve as co-chair of the two JCORE subcommittees noted above, working closely with the White House, other federal science funding agencies, and intelligence and law enforcement communities; (2) facilitate NSF's access to classified information and ability to engage in classified discussions with other U.S. government agencies, including through the addition of a Sensitive Compartmented Information Facility at NSF's headquarters; and (3) continue evaluation of recommendations to consider implementing additional policy steps and/or outreach activities related to research security at both the agency level and the JCORE level.

# Performance

NSF's Strategic Plan for FY 2018 – 2022, *Building the Future: Investing in Discovery and Innovation,*[21] establishes two strategic goals that capture the dual nature of NSF's mission to advance the progress of science while benefitting the Nation: *Expand knowledge in science, engineering, and learning* and *Advance the capability of the Nation to meet current and future challenges*. A third goal, *Enhance NSF's performance of its mission*, directs NSF to hold itself accountable for achieving excellence in carrying out its mission. As shown in the following table, each goal has two strategic objectives which together encompass all areas of agency activity. This goal structure enables NSF to link its investments to longer-term outcomes.

**Strategic Goals and Objectives**

| Strategic Goals | Strategic Objectives |
|---|---|
| Expand knowledge in science, engineering, and learning | *1.1 Knowledge*<br>Advance knowledge through investments in ideas, people, and infrastructure. |
| | *1.2 Practice*<br>Advance the practice of research. |
| Advance the capability of the Nation to meet current and future challenges | *2.1 Societal Impacts*<br>Support research and promote partnerships to accelerate innovation and to provide new capabilities to meet pressing societal needs. |
| | *2.2 STEM Workforce*<br>Foster the growth of a more capable and diverse research workforce and advance the scientific and innovation skills of the Nation. |
| Enhance NSF's performance of its mission | *3.1 Human Capital*<br>Attract, retain, and empower a talented and diverse workforce. |
| | *3.2 Processes and Operations*<br>Continually improve agency operations. |

In FY 2020, NSF updated its Partnerships-focused Agency Priority Goal (APG): *Strategically engage in public and private partnerships to enhance the impact of NSF's investments and contribute to American economic competitiveness and security*.[22,23] The APG states that by September 30, 2021, NSF will develop and pursue an agency-wide partnerships strategy, components of which will include targeted outreach, implementation of process improvements, and improvement of internal and external communications. In FY 2020, NSF continued its practice of having agency leaders conduct quarterly data-driven performance reviews, including reporting on the APG.

NSF participates actively in the President's Management Agenda, most prominently in the implementation of Cross-Agency Priority (CAP) Goals relevant to its mission. For example, as a member of the Executive Steering Committee for CAP Goal 8, Results-Oriented Accountability for Grants,[24] NSF contributed to the revisions OMB released to Title 2 of the Code of Federal Regulations. This government-

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[21] *NSF Strategic Plan FY 2018 – 2022*: https://www.nsf.gov/pubs/2018/nsf18045/nsf18045.pdf

[22] Agency Priority Goal – Expand Public and Private Partnerships: https://www.performance.gov/NSF/APG_nsf_1.html

[23] NSF has strategic public-private partnerships that do not meet the thresholds governing financial reporting, per the Statement of Federal Financial Accounting Standards (SFFAS) 49, "Private Public Partnership: Disclosure Requirements."

[24] CAP Goal 8: https://www.performance.gov/CAP/CAP_goal_8.html

wide policy revision marks the beginning of a foundational shift toward results-oriented accountability for federal grants.



**App catches early signs of eye disease**

Smart phones have been put to an astounding number of innovative uses. Now, with funding from NSF, researchers are making them important tools for the early detection of certain eye diseases. Signs of a rare form of eye cancer known as retinoblastoma can show up in smart phone photos in the form of a telltale white sheen that comes from light reflecting off tumors in the back of the eyes. The white reflections that can appear in photos might also indicate cataracts, infections, or other disorders. The researchers are using machine learning to power a smart phone app that can identify potential abnormalities. While the app can't take the place of a doctor's diagnosis, in places where cellphones are common but medical care is limited, the technology could make the difference in timely medical intervention for countless people.

Examples of what a smart phone app looks for: The white reflection from an otherwise dark pupil can indicate a tumor, a cataract or other eye problems. *Credit: Claire Eggers/NPR.*

## Progress Toward Achievement of Performance Goals

Each year, NSF produces an *AFR, APR*, and a *Performance and Financial Highlights* summary report. NSF's *FY 2020 APR* will appear in the *FY 2022 Budget Request* as part of an integrated Performance Plan and Report. This report will provide a complete discussion of NSF's performance measures, including descriptions of the metrics, methodologies, results, and trends, along with a list of relevant external reviews. The topic areas of these goals are listed in the following table. Targets and annual results will be provided in the *FY 2020 APR*. Where appropriate, results will incorporate a discussion about the effects of the COVID-19 pandemic on performance. The *FY 2020 APR* will also provide information about NSF's verification and validation review of performance data, as required by the Government Performance and Results Modernization Act of 2010. NSF's *FY 2020 APR* (included in the *FY 2022 Budget Request to Congress)* and *FY 2020 Performance and Financial Highlights* summary report will be posted on the NSF website concurrent with NSF's *FY 2022 Budget Request to Congress* in 2021.[25]

### FY 2020 Performance Goals

| Goal Short Name | Goal Statement |
|---|---|
| *APG*: Public and Private Partnerships | *APG*: Strategically engage in public and private partnerships to enhance the impact of NSF's investments and contribute to American economic competitiveness and security. |
| Ensure that Key Program Investments are on Track | Ensure that key NSF-wide program investments are implemented and on track. |
| Ensure that Infrastructure Investments are on Track | Ensure program integrity and responsible stewardship of major research facilities and infrastructure. |
| Make Timely Proposal Decisions | Inform applicants whether their proposals have been declined or recommended for funding in a timely manner. |

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[25] *FY 2020 Agency Performance Report* (included in the Performance chapter of the FY 2022 Budget Request to Congress) and *FY 2020 Performance and Financial Highlights*: https://www.nsf.gov/about/performance/

| Goal Short Name (continued) | Goal Statement |
|---|---|
| Improve Review Quality | Improve the quality of written reviews of NSF proposals. |
| Foster a Culture of Inclusion | Foster a culture of inclusion through change management efforts resulting in change leadership and accountability. |
| Align Job Requirements with Competencies | Ensure that employee job requirements are aligned with competencies and skills needed for the future. |
| Improve User Interactions with Information Technology (IT) Systems | Streamline and simplify user interactions with IT systems and functions that support the merit review process, reducing non-value-added steps and reducing the time spent managing the proposal and award lifecycle. |

## Renewing NSF

In FY 2020, NSF continued ongoing efforts focused on internal agency reform and process improvement, collectively called "Renewing NSF." Renewing NSF aims to enhance performance of NSF's mission and maintain U.S. leadership in research and education across all areas of STEM. This effort is aligned with NSF's history of continuous organizational improvement and the Administration's government-wide agency reform activities, and it will yield an even more agile organization better prepared for future challenges and opportunities. The four focus areas are: (1) making information technology work even better for all; (2) adapting the workforce and the work; (3) streamlining, standardizing, and simplifying processes and practices; and (4) expanding and deepening public and private partnerships. NSF has performance goals supporting all four areas.



*NSF funds the design, development, and deployment of city-scale advanced wireless testing platforms that will enable experimentation and unleash new approaches and possibilities for next-generation wireless networks. Credit: PAWR Project Office.*

*Platforms for Advanced Wireless Research (PAWR)*

Expanding the reach of high-speed Internet connectivity is critical to boosting economic productivity, educational opportunities, and other benefits to communities around the nation. Through PAWR, NSF is partnering with a consortium of more than 35 companies to stand up four city-scale testing platforms. These platforms are in turn enabling experimentation with novel wireless concepts, protocols, technologies, and applications and services. With platforms currently based in Salt Lake City, New York City, and North Carolina's Research Triangle, PAWR is moving forward with plans for a fourth testing platform to focus on rural broadband technology, with an eye toward reducing access costs for rural communities and integrating multiple wireless technologies in new ways to reach unserved and underserved areas.

## Proposal Workload and Management Trends

NSF continuously monitors key portfolio, proposal workload, and financial measures to understand short- and long-term trends and to help inform management decisions. For an analysis of the long-term trends in competitive proposals, awards, funding rate, and other portfolio metrics, see the *National Science Foundation's Merit Review Process, Fiscal Year 2018 Digest*.[26]

Figure 1.5 identifies three key portfolio measures: competitive proposals acted upon, new awards, and funding rates. In FY 2020 there were increases in all three key measures.



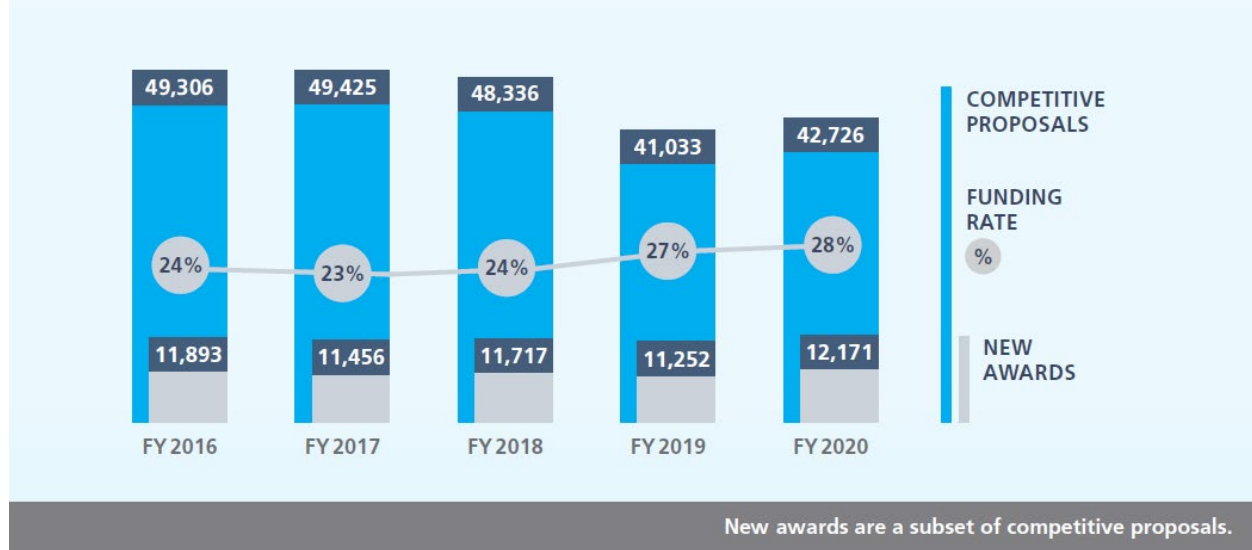Figure 1.5. Number of NSF Competitive Proposals, New Awards and Funding Rates

Table 1.2 provides proposal workload and management trends over 5 years. Highlights of these indicators are as follows:

- Between FY 2019 and FY 2020, the number of competitive proposal actions increased by 4 percent; from 41,033 to 42,726.

- The number of new awards in FY 2020 was 12,171, an 8 percent increase over FY 2019.

- The overall funding rate in FY 2020 was 28 percent, an increase of 1 percentage point. Funding rates differ by directorate and are presented in the agency's annual budget request to Congress.

- The average annual award size of competitive awards was $213,280, approximately $16,000 higher than in FY 2019. As shown in Table 1.2, award size varies by year. The average annual award size has been increasing over the past 3 years.

- The number of employees (FTEs) increased slightly between FY 2019 and FY 2020, 1,415 FTE and 1,421 FTE, respectively.

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[26] *NSF's Merit Review Process, FY 2018 Digest* (NSB-2020-13): https://www.nsf.gov/nsb/publications/2020/nsb202013.pdf

- The number of active awards increased 2 percent in FY 2020, from 54,093 in FY 2019 to 55,239 in FY 2020. The 5-year average number of active awards is 54,593.

**Table 1.2 Proposal Workload and Management Trends**

| | Measure | FY 2016 | FY 2017 | FY 2018 | FY 2019 | FY 2020 | Percent Change (FY 2020-FY 2019) | Average (FY 2016-FY 2020) |
|---|---|---|---|---|---|---|---|---|
| **Portfolio** | Competitive proposal actions | 49,306 | 49,425 | 48,336 | 41,033 | 42,726 | 4.1% | 46,165 |
| | Competitive award actions | 11,893 | 11,456 | 11,717 | 11,252 | 12,171 | 8.2% | 11,698 |
| | Average annual award size (competitive awards) | $176,243 | $174,533 | $189,418 | $197,530 | $213,280 | 8.0% | $190,201 |
| | Funding rate | 24% | 23% | 24% | 27% | 28% | +1 percentage point | 25% |
| **Proposal Workload** | Number of employees FTE, usage[1] | 1,398 | 1,430 | 1,417 | 1,415 | 1,421 | 0.4% | 1,416 |
| | Number of active awards[2] | 54,439 | 54,806 | 54,386 | 54,093 | 55,239 | 2.1% | 54,593 |
| | Proposal reviews conducted[3] | 225,017 | 231,691 | 223,781 | 192,033 | 199,526 | 3.9% | 214,410 |
| **Financial** | Number of grant payments | 22,926 | 22,615 | 21,727 | 20,935 | 22,169 | 5.9% | 22,074 |
| | Award expenses incurred but not reported at 9/30 ($ in millions)[4] | $366 | $397 | $393 | $425 | $437 | 2.8% | $402 |

**Notes:**

[1] FTEs shown include the federal employee workforce for NSF, NSB, OIG, and U.S. Arctic Research Commission.

[2] Active awards include all active awards regardless of whether funds were received during the fiscal year.

[3] Includes written reviews, panel summaries, and site visit reports. In FY 2017, system changes implemented additional categories of panelist roles. Beginning in FY 2018, reviews conducted by these roles are included in the review counts, and FY 2017 was revised for historical consistency.

[4] FY 2020 number reflects an accrual, and all other years reflect actuals estimate.

- All NSF awardee institutions are required to submit payment requests at the award level to the NSF Award Cash Management Service (ACM$). Award expenses are posted to the NSF financial system at the time of the payment request. Reliance on ACM$ reduces the burden of manual invoicing and potential for errors or missed payments.

- Since its introduction in FY 2013, ACM$ has significantly improved the timeliness of grant financial data. Prior to ACM$, NSF awardee institutions using quarterly expense reporting processes had approximately $1.7 billion in award expenses that they had incurred but not-yet-reported to NSF on September 30. With the use of ACM$, the amount of incurred but not-yet-reported award expenses have averaged $402 million for each of the last 5 years.
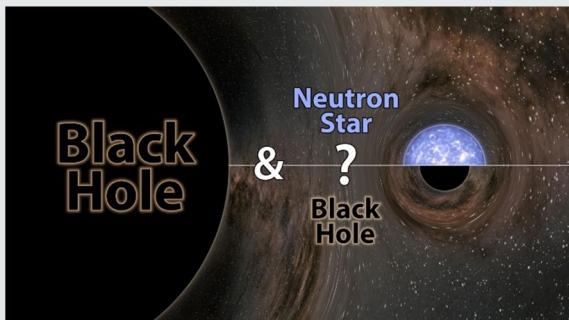
**The LIGO-Virgo gravitational-wave network witnessed the merger of a black hole and a mystery object.** *Credit: LIGO/Caltech/ MIT/R. Hurt (IPAC).*

***LIGO-Virgo finds mystery object in gap between neutron stars and black holes***

When the Laser Interferometer Gravitational-Wave Observatory—known as LIGO—detected gravitational waves for the first time in 2016, it sent shockwaves through the scientific community, confirming predictions made by Albert Einstein a century before in a feat of research that some thought would be impossible to achieve. LIGO is continuing to make breakthroughs, detecting cosmic collisions between black holes and neutron stars, and answering key questions about our universe. One of those questions revolves around the "mass gap"—a blank space in astrophysicists' data between the largest neutron stars ever detected and the smallest black hole. At the end of their lifetimes, larger stars collapse into black holes, while smaller stars leave behind ultra-dense neutron stars. Since normal stars come in a spectrum of sizes, astrophysicists have been puzzled by the gap between neutron stars and black holes. A new LIGO discovery in 2020 provided evidence of an object firmly in the "mass gap" range. Whether it's record-breaking neutron star or a mini-black hole, the discovery is helping scientists get a clearer picture of some of the most exotic phenomena in the universe.

# Financial Discussion and Analysis

In FY 2020, NSF demonstrated its commitment to financial management excellence and support of the agency's mission through a set of activities spanning Enterprise Risk Management (ERM), internal control, data science, and financial system improvements. Financial highlights from the year include:

- *Enterprise Risk Management*: The Foundation continued to increase the maturity of its ERM community of practice through formalizing ERM governance structure and practices. This change allows the agency to identify threats and opportunities more effectively at both the operational and leadership levels. The agency also leveraged and expanded ERM in its day-to-day decision making to better respond to the risks presented by the COVID-19 pandemic. This experience has positioned NSF to be able to identify and address potential risk events in the future.

- *G-Invoicing*: NSF continued to participate in the government-wide long-term solution to improve the management and accounting of Interagency Agency Agreements (IAAs). This online, user-friendly platform will eliminate manual processes by tracking IAA information automatically and enhance the management and transparency of these agreements. G-Invoicing aligns with three of the Renewing NSF initiative's pillars: making information technology work for all; streamlining, standardizing, and simplifying processes and practices; and expanding and deepening public and private partnerships. The agency has established a project team to support the initiation, design, and deployment of G-Invoicing. In addition, NSF formed a G-Invoicing Stakeholders Working Group to engage program staff throughout the project.

- *DATA Act*: NSF continued its lead role working with the Department of Treasury (Treasury) to test financial system changes. In July 2020, the Foundation successfully implemented the legislative requirements of OMB M-20-21, *Implementation Guidance for Supplemental Funding Provided in Response to the Coronavirus Disease*, which required monthly reporting for all agencies receiving COVID-19 supplemental funding, and special designation of awards issued in response to COVID-19. To successfully implement these requirements, the Foundation changed its systems, processes, and controls, and provided coordination and communication among operational units. The agency also updated its Data Quality Plan to incorporate new enhancements required to implement OMB guidance. The plan provides an executive-level summary of the agency's controls across people, processes, and technology for DATA Act reporting to ensure the completeness, accuracy, and timeliness of monthly submissions.

- *NSF Financial Transparency Tool*: This year, BFA continued to enhance the timeliness and access to spending information by creating a module in its financial reporting system available to all NSF staff. Using the Transparency Tool, NSF published the executive dashboard, called "The Quad," to provide senior leaders with timely financial indicators for decision-making. Throughout the year, several enhancements were made based on agency-wide user feedback.

- *Monitoring COVID-19 Financial Resources*: To assist in expediting the award of CARES Act funding, NSF created a daily report that was provided to Program Offices and the Division of Grants and Agreements. The report helped ensure an accelerated flow of CARES Act funds. Further, NSF developed a COVID-19 funding dashboard that allowed the agency to monitor financial indicators associated with COVID-related research activities and assist with decision-making and oversight.

- *Blockchain*: NSF continued its partnership with Treasury's Office of Financial Innovation and Transformation on a proof-of-concept pilot using blockchain distributed ledger technology (DLT). The concept focuses on the grant payment process and providing enhanced transparency in multi-tiered grant payments. The current phase of this forward-looking pilot has been expanded to additional federal agencies and research universities to develop requirements on how DLT can best address current grant reporting concerns and increase the efficiency of the grant payment process.

In accordance with the Chief Financial Officers (CFO) Act and the Government Management Reform Act of 1994, NSF prepares financial statements in conformity with Generally Accepted Accounting Principles (GAAP) for federal entities. The financial statements present NSF's detailed financial information relative to its mission and the stewardship of resources entrusted to the agency. They also provide readers with an understanding of the resources that NSF has available, the cost of its programs, and the status of resources at the end of the fiscal year. NSF's financial statements have undergone an independent audit to ensure that they are free from material misstatement and can be used to assess NSF's financial status and related financial activities for the year ending September 30, 2020.

NSF received an unmodified audit opinion on its financial statements, and no material weaknesses or significant deficiencies were identified in the internal control program for financial reporting. The Independent Auditor's Report begins on the first page of Chapter 2, *Financials*. Management's response follows the audit report.

## Understanding the Financial Statements

The following discussion of NSF's financial condition and results of operations should be read together with the FY 2020 financial statements and accompanying notes, found in Chapter 2, Financials, of this *AFR*.

In accordance with guidance in OMB Circular No. A-136, *Financial Reporting Requirements,* NSF's FY 2020 financial statements and notes are presented in a comparative format to facilitate analysis of FYs 2020 and 2019. Table 1.3 summarizes the changes in NSF's financial position in FY 2020 relative to FY 2019.

**Table 1.3 – Changes in NSF's Financial Position in FY 2020**
(Dollars in Millions)

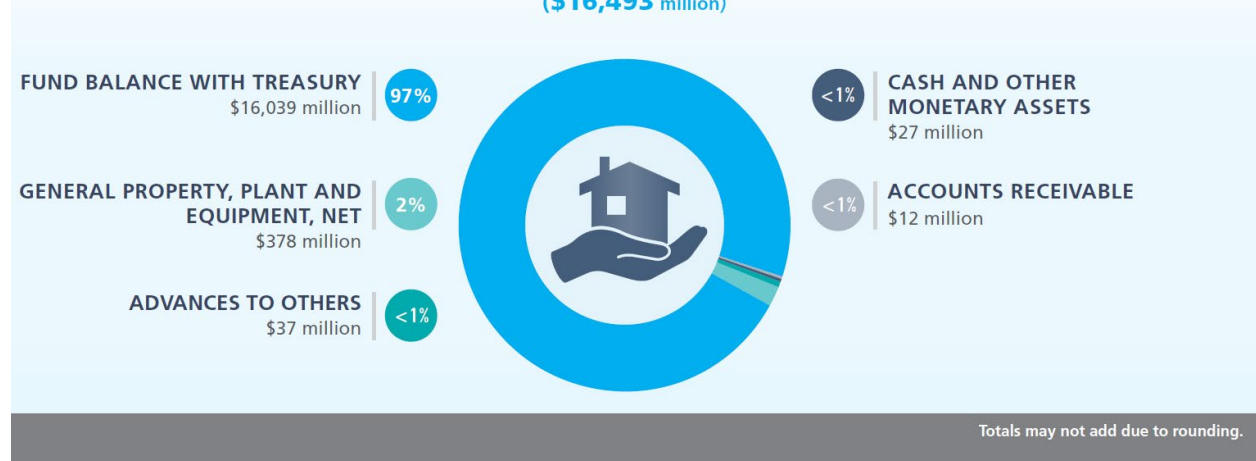| Net Financial Condition | FY 2020 | FY 2019 | $ Change | % Change |
|---|---|---|---|---|
| Assets | $16,493 | $15,295 | $1,198 | 8% |
| Liabilities | $633 | $541 | $92 | 17% |
| Net Position | $15,860 | $14,754 | $1,106 | 7% |
| Net Cost | $7,355 | $7,320 | $35 | <1% |

### Balance Sheet

The Balance Sheet presents the total amounts available for use by NSF (assets) against the amounts owed (liabilities) and amounts that comprise the difference (net position). NSF's total assets are largely composed of *Fund Balance with Treasury*.
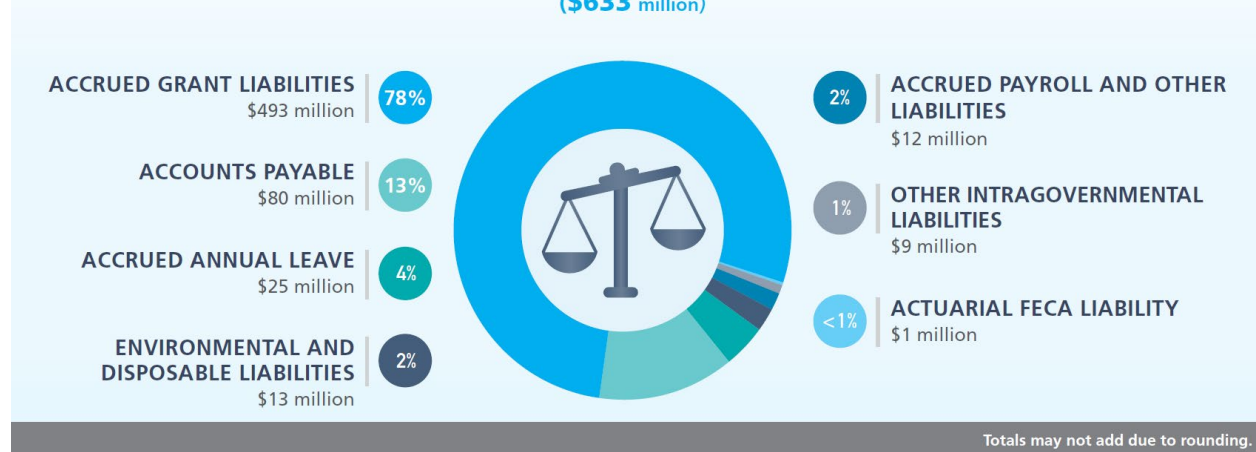
In FY 2020, Total Assets increased 8 percent from FY 2019 (see Figure 1.6). The majority of the change occurred in the *Fund Balance with Treasury* account, which increased by $1.141 million in FY 2020. NSF is authorized to use *Fund Balance with Treasury* to make expenditures and pay amounts due through the disbursement authority of Treasury. The *Fund Balance with Treasury* is increased through appropriations and collections and decreased by expenditures and rescissions.

## Figure 1.6. FY 2020 ASSETS
### ($16,493 million)

| | |
|---|---|
| **FUND BALANCE WITH TREASURY** $16,039 million — 97% | **CASH AND OTHER MONETARY ASSETS** $27 million — <1% |
| **GENERAL PROPERTY, PLANT AND EQUIPMENT, NET** $378 million — 2% | **ACCOUNTS RECEIVABLE** $12 million — <1% |
| **ADVANCES TO OTHERS** $37 million — <1% | |

Totals may not add due to rounding.

In FY 2020, Total Liabilities increased 17 percent over FY 2019 (see Figure 1.7). Driving this change was an $80 million increase in *Accrued Grant Liabilities* in FY 2020. *Accrued Grant Liabilities* consist of estimated liabilities for grant expenses incurred but not reported for standard grants and cooperative agreements, and SBIR and Small Business Technology Transfer (STTR) grants.

## Figure 1.7. FY 2020 LIABILITIES
### ($633 million)

| | |
|---|---|
| **ACCRUED GRANT LIABILITIES** $493 million — 78% | **ACCRUED PAYROLL AND OTHER LIABILITIES** $12 million — 2% |
| **ACCOUNTS PAYABLE** $80 million — 13% | **OTHER INTRAGOVERNMENTAL LIABILITIES** $9 million — 1% |
| **ACCRUED ANNUAL LEAVE** $25 million — 4% | **ACTUARIAL FECA LIABILITY** $1 million — <1% |
| **ENVIRONMENTAL AND DISPOSABLE LIABILITIES** $13 million — 2% | |

Totals may not add due to rounding.

In FY 2020, NSF implemented a new accrual methodology for SBIR/STTR grants based on their unique terms and conditions. This new accrual methodology resulted in $56 million of the total increase to *Accrued Grant Liabilities*. The accrual for standard grants and cooperative agreements is estimated annually by utilizing a linear regression model based on the statistical correlation of NSF grantees' historical unliquidated obligations and expenses incurred but not reported. In FY 2020, the unliquidated obligations balance for grantees increased, resulting in $24 million of the total increase in *Accrued Grant Liabilities* as compared to FY 2019.
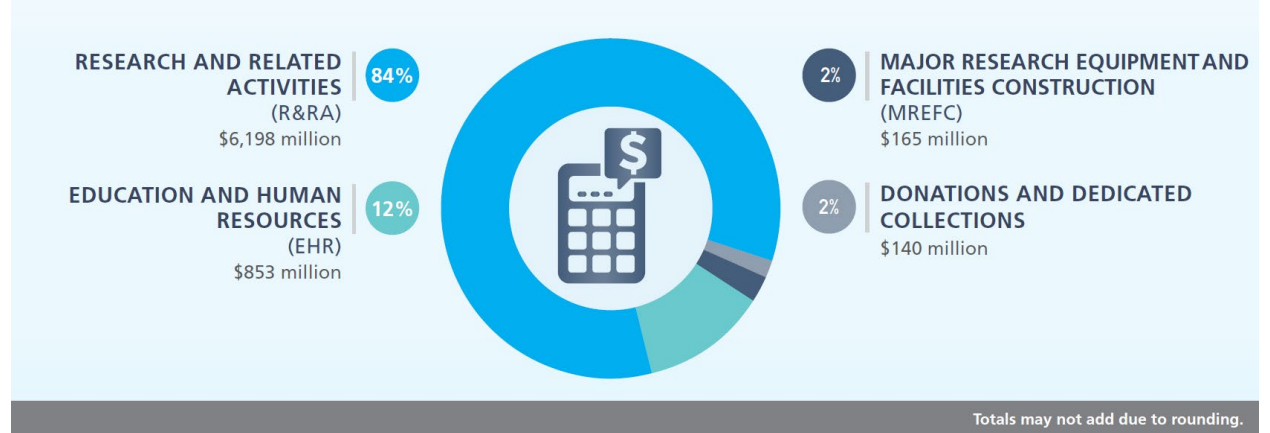
NSF's assets and liabilities were impacted by appropriated funds related to the CARES Act, primarily in support of R&RA activities related to COVID-19. As of September 30, 2020, NSF had $59 million in assets and $2 million in liabilities for COVID-19-related activities.

### Statement of Net Cost
The Statement of Net Cost presents the annual cost of operating NSF programs. The net cost of operations of each NSF program equals the program's gross cost less any offsetting revenue. Intragovernmental earned revenues are recognized when related program or administrative expenses are incurred. Earned revenue is deducted from the full cost of the programs to arrive at the *Net Cost of Operations*.

Approximately 95 percent of FY 2020 *Net Cost of Operations* was directly related to the support of R&RA, EHR, MREFC, and Donations and Dedicated Collections. Additional costs were incurred for indirect general operation activities (e.g., salaries, training, and activities related to the advancement of NSF information systems technology) and activities of the NSB and the OIG. These costs were allocated to R&RA, EHR, MREFC, and Donations and Dedicated Collections and account for approximately 5 percent of FY 2020 *Net Cost of Operations* (see Figure 1.8). These administrative and management activities support the agency's program goals. Net Costs related to the CARES Act appropriations for R&RA, EHR, and AOAM were $18 million, $1 million, and $300,000, respectively.



Figure 1.8. FY 2020 NET COST
($7,355 million)

RESEARCH AND RELATED ACTIVITIES (R&RA) — 84% — $6,198 million

EDUCATION AND HUMAN RESOURCES (EHR) — 12% — $853 million

MAJOR RESEARCH EQUIPMENT AND FACILITIES CONSTRUCTION (MREFC) — 2% — $165 million

DONATIONS AND DEDICATED COLLECTIONS — 2% — $140 million

Totals may not add due to rounding.

### Statement of Changes in Net Position
The Statement of Changes in Net Position presents the agency's cumulative results of operations and unexpended appropriations for the fiscal year. NSF's *Total Budgetary Financing Sources*, as part of *Unexpended Appropriations*, increased by $193 million; and *Total Financing Sources*, as part of *Cumulative*

*Results of Operations*, increased by $54 million in FY 2020 for a total increase of $247 million. *Cumulative Results of Operations* increased by $89 million.

Appropriations from the CARES Act resulted in Unexpended Appropriations of $57 million in FY 2020. As NSF continues to provide support for COVID-19 related research, costs will increase, which will lead to a decrease in net position.

### Statement of Budgetary Resources

This statement provides information on how budgetary resources were made available to NSF for the year and the status of those budgetary resources at year end. For FY 2020, *Total Budgetary Resources* increased $295 million from the FY 2019 level. *Budgetary Resources—Appropriations* in FY 2020 for the R&RA, EHR, and MREFC accounts were $6,790 million, $943 million, and $243 million, respectively. The combined *Budgetary Resources—Appropriations* in FY 2020 for the NSB, the OIG, and AOAM accounts totaled $378 million. NSF also received funding via warrant from the H-1B Nonimmigrant Petitioner Account (H-1B) in the amount of $154 million and via funds from foreign governments, private companies, academic institutions, nonprofit foundations, and individuals in the amount of $27 million. In FY 2020, the *Budgetary Resources—Appropriations* line was also affected by H-1B sequestration in the amount of $9 million.

NSF received $76 million in CARES Act funding in support of the national response to COVID-19. NSF obligated $70 million for R&RA, $5 million for EHR, and $1 million for AOAM. Budget authority provided by the CARES Act is available to NSF for obligation through September 2021. As of September 30, 2020, all funds were obligated.

### Limitations of the Financial Statements

In accordance with the guidance provided in OMB Circular No. A-136, NSF discloses the following limitations of the agency's FY 2020 financial statements. The principal financial statements are prepared to report the financial position and results of operations of NSF, pursuant to the requirements of 31 U.S.C. 3515(b). The statements are prepared from the books and records of NSF in accordance with federal GAAP and the formats prescribed by OMB. Reports used to monitor and control budgetary resources are prepared from the same books and records. Users of the statements are advised that the statements are for a component of the U.S. Government.

## Other Financial Reporting Information

### Debt Collection Improvement Act of 1996

*Net Accounts Receivable* totaled $12.3 million at September 30, 2020. Of that amount, $11.4 million was due from other federal agencies. The remaining $900,000 was due from the public. In accordance with the Debt Collection Improvement Act, as amended by the DATA Act, NSF fully participates in Treasury's Cross-Servicing Program. This program requires NSF to refer debts due from the public that are delinquent more than 120 days to Treasury for appropriate collection action. In accordance with OMB Circular No. A-129, "Policies for Federal Credit Programs and Non-Tax Receivables," NSF writes off delinquent debt that is more than 2 years old. Additionally, NSF seeks Department of Justice concurrence for the write-off of debts greater than $100,000.

### Cash Management Improvement Act of 1990

In FY 2020, NSF had no awards covered under Cash Management Improvement Act Treasury-State Agreements. The timeliness of NSF's payments to grantees through its payment systems makes the issue of timeliness of payment under the Act essentially not applicable to the agency. No interest payments were made in FY 2020.

### Scientists discover how cyanobacteria thrive in low light

Cyanobacteria are tiny organisms that live virtually everywhere on Earth and use weak, filtered sunlight to generate energy through photosynthesis. They helped create an oxygen-rich atmosphere and continue to provide us with much of the oxygen we need to survive. Now, with funding from NSF, researchers have mapped the structure of the protein complex that allows cyanobacteria to live on such small amounts of light. The results could be used to engineer crops that thrive under low-light conditions, making the production of some crops less energy-intensive and more bountiful.
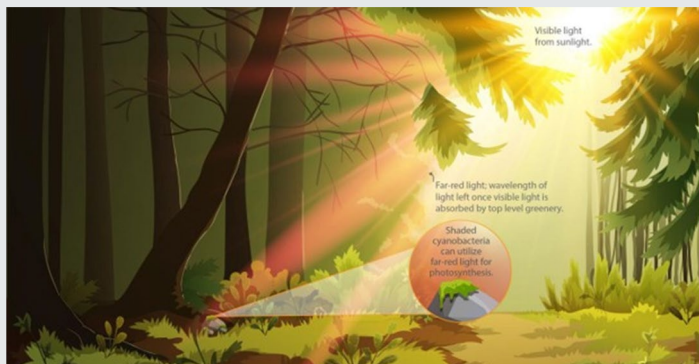


When cyanobacteria live in low-light conditions, some can switch to using far-red sunlight. *Credit: Shireen Dooling, Graphic Designer, ASU Biodesign Institute.*

# Systems, Controls, and Legal Compliance

## Management Assurances

**National Science Foundation**

**FY 2020 Statement of Assurance**

The National Science Foundation (NSF) management is responsible for managing risks and maintaining effective internal control to meet the objectives of Sections 2 and 4 of the Federal Managers' Financial Integrity Act (FMFIA). The NSF conducted its assessment of risk and internal control processes in accordance with OMB Circular No. A-123, *Management's Responsibility for Enterprise Risk Management and Internal Control*. Based on the results of the assessment, NSF can provide reasonable assurance that internal control over operations, reporting, and compliance was operating effectively as of September 30, 2020.

**/s/**
**Sethuraman Panchanathan**
Director

November 13, 2020

The Federal Managers' Financial Integrity Act of 1982 (FMFIA)[27] and the OMB Circular A-123, *Management's Responsibility for Enterprise Risk Management and Internal Control*[28] require NSF to evaluate its systems of internal control and provide reasonable assurance to the President and the Congress on the adequacy of those systems, annually.

This year, NSF continued the work to transition its highly successful Internal Control and Quality Assurance Program to the Data Analytics & Assurance Program. NSF began to realize benefits associated with introducing analytics to internal control monitoring, in terms of increasing effectiveness and facilitating a shift to higher-value work. Specific areas of focus include: (1) dealing with the proliferation of data; (2) leveraging artificial intelligence and automation; (3) managing and reducing the cost of compliance efforts; and (4) building even stronger organizations.

The FY 2020 unmodified Statement of Assurance, with no material weaknesses, is reasonable assurance to the overall adequacy and effectiveness of internal controls based upon information that the system of internal control is operating as intended.

NSF's internal control assessment provides reasonable assurance that the objectives of FMFIA and the FFMIA were achieved and that the internal control process over reporting is effective.

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[27] FMFIA: https://www.whitehouse.gov/sites/whitehouse.gov/files/omb/financial/fmfia1982.html
[28] *OMB Circular A-123*: https://www.whitehouse.gov/sites/whitehouse.gov/files/omb/memoranda/2016/m-16-17.pdf

## Highlights from NSF's FY 2020 Data Analytics and Assurance Program

In FY 2020, the NSF Data Analytics and Assurance Program completed ERM, internal control, and data science initiatives to maintain and modernize the agency's strong control environment. The team also focused on change management and stakeholder engagement, working across the agency to engage personnel on risk management conversations and activities. This renewed focus on communications and engagement generated new insights and increased transparency into enterprise-level and internal control risks. The following list highlights the FY 2020 initiatives from the Data Analytics and Assurance Program:

- *Entity Level Control Checks:* As part of validating approach and identifying areas for continual improvement, NSF completed an entity-level design assessment to consider coverage and maturity in key ERM and internal control practices. NSF used the results of the entity level control checks to build consensus on areas of focus.

- *ERM Governance Improvement Initiative:* NSF focused on activating its ERM governance structure, including providing opportunities for senior-level functional leaders to discuss enterprise-level risks and coordinate management of these risks and reporting on ERM to NSF leadership.

- *Enhanced Risk and Control Checkpoints:* NSF assessed its risk and control landscape to identify areas of potential elevated risks associated with the COVID-19 pandemic, including the risk of fraudulent activities by internal and external parties. NSF reviewed the elevated risk areas with process owners and updated levels of risk and control activities to stay abreast of key monitoring activities and changes to fraud indicators.

- *Improper Payments Predictive Modeling:* Considering the changes to the improper payments risk landscape associated with the COVID-19 pandemic, NSF built a risk model to use Single Audit data to provide a quantitative view of which NSF awardees may present relatively higher risk of improper payments in the future. This will help the agency address improper payments risk, including fraud risk, with targeted monitoring and avoid undue compliance burden on NSF staff and grantees. NSF's improper payment risk assessment is described in the section, *Requirements for Effective Estimation and Remediation of Improper Payments*.

- *Travel Card Misuse Monitoring:* NSF increased the efficiency of its mature process for effectively identifying and monitoring potential travel card misuse by automating key data sources to create a dashboard. This new tool displays key indicators and increases transparency into potential misuse, including fraud, and associated follow-ups, while decreasing staff burden.

### *Management of ERM and Internal Control—OMB Circular A-123, Appendix A*
NSF continued strengthening internal controls over financial reporting, conducted in support of program integrity and in alignment with OMB Circular A-123, the Green Book, and the Committee of Sponsoring Organizations of the Treadway Commission's (COSO's) Internal Control Integrated Framework and Internal Control Over Financial Reporting Compendium of Approaches and Examples. In addition, NSF continued to steadily increase the maturity of its ERM program in alignment with COSO's ERM Integrated Framework, as well as the risk-based assurance requirements of OMB and GAO. Some of the areas of focus for NSF in assessing its internal controls in FY 2020 included grants management, financial reporting, DATA Act, and IT general controls (ITGCs). In all cases, the team focused on confirming design and operating effectiveness of existing controls, with an eye to identifying new ways to leverage technology that further improves effectiveness and streamlines level-of-effort associated with monitoring.

### *Improving the Management of Government Charge Card Programs—OMB Circular A-123, Appendix B*

NSF continues to maintain strong controls and effective monitoring over its government charge card programs. In FY 2020, this verification of the internal control environment included bi-annual reviews of the charge card risk landscape and NSF's key controls related to government charge card program management and oversight. Also, NSF completed process enhancements and developed a Travel Card Misuse Dashboard to streamline the completion of its monthly travel card misuse review process and provide additional transparency into the results of the reviews.

### *Requirements for Effective Estimation and Remediation of Improper Payments—OMB Circular A-123, Appendix C and the Payment Integrity Information Act of 2019 (PIIA):*

Historically, NSF has had low risk and incidence of improper payments. In FY 2020, NSF moved its grants payments testing into the current year to identify and respond to improper payment risk in a timelier manner. Testing results indicated a similarly low risk of improper payments within NSF's grants program as the prior year qualitative risk assessment. In addition, NSF re-evaluated its improper payment risk assessment activities to focus on the most effective methodology to assess external risk of improper payments in the grants program, given the potential for heightened risk associated with the COVID-19 pandemic. NSF is designing an FY 2021 improper payments risk assessment, which will be aligned with requirements of OMB Circular A-123, Appendix C, and the PIIA. NSF will employ quantitative and qualitative methodologies to assess improper payment risk for its grants and mission support programs, including for the Small Business Innovation Research/Small Business Technology Transfer programs. NSF will monitor and address any risks it identifies in accordance with the agency's ERM governance structure.

### *Compliance with the FFMIA —OMB Circular A-123, Appendix D*

OMB Circular A-123, Appendix D provides guidance in determining compliance with FFMIA for agencies subject to the Chief Financial Officers Act of 1990. NSF leveraged work previously described under Appendix A, including the ITGC assessment and active participation in the Statement of Standards for Attestation Engagements (SSAE 18) review process. In particular, the SSAE 18 process as it relates to the NSF financial management system (iTRAK) service provider includes verifying that NSF has the appropriate controls designed and in place to support responsible reliance on the financial system, including Complementary User Entity Controls. NSF's service provider received a clean opinion on the Service Auditor Type 2 System and Organization Controls Report, which is relevant to internal control over financial reporting. The auditors' opinion addressed the accuracy and completeness of the design of controls and services. No significant deficiencies or material weaknesses in internal control over FFMIA compliance were identified.

*Federal Information Security Modernization Act (FISMA) of 2014:* NSF has established a comprehensive IT Security and Privacy Program that is consistent with FISMA and industry best practices. NSF's IT controls are effective in maintaining a secure IT environment and align with the National Institute of Standards and Technology (NIST) Framework for Improving Critical Infrastructure. The agency's IT environment is supported by a suite of comprehensive policies and procedures that incorporate federal mandates and guidance. NSF has a strong Information Security Continuous Monitoring program that includes the Department of Homeland Security Continuous Diagnostic and Mitigation technologies. NSF includes cybersecurity as part of its ERM program; the cognizant ERM Risk Captain revisits the "Maintaining Cybersecurity" risk profile periodically to ensure that it accurately reflects the current enterprise-level risk and the risk responses are appropriate for NSF's risk appetite and tolerance.

***Understanding the Source of Creative Breakthroughs***

Can you see a lightbulb go off over someone's head when they have a great idea? NSF-funded researchers saw the next closest thing. Using high-density electroencephalograms (EEGs), researchers took snapshots of the burst of brain activity that accompanies "aha!" moments. The increase in neural activity that accompanies creative insights is tied to the brain's reward center, and the study showed that the reward was triggered by the moment of insight before people even had a chance to make a conscious appraisal of the idea. The connection between creative insights and the brain's reward center can help scientists understand how the brain may have evolved to encourage creativity and thereby fostered the progress of science, art, industry, and culture for generations.

**Researchers prepare a test subject by dispensing conductive electrode gel into the electrodes in an EEG cap.** *Credit: John Kounios, Drexel University.*

### *Other Federal Reporting and Disclosure*

*Antideficiency Act (ADA)*: NSF is not aware of any ADA violations that are required to be reported for the year ended September 30, 2020.

*DATA Act*: The DATA Act is a government-wide initiative led by OMB and Treasury to standardize and publish the federal government's wide variety of reports and data compilations related to spending. NSF developed its initial Data Quality Plan (DQP) to document the agency's approach to complying with the DATA Act and achieving reasonable assurance for internal control over DATA Act reporting. In FY 2020, NSF reevaluated this control baseline and updated the DQP. The DQP update incorporated DATA Act reporting requirements for federal agencies that received COVID-19 supplemental appropriations. The new reporting requirements were issued in OMB M-20-21, *Implementation of Guidance for Supplemental Funding Provided in Response to the Coronavirus Disease 2019 (COVID-19),* and the Treasury's DAIMS v2.0. In FY 2020, NSF successfully transitioned to the monthly reporting required under DAIMS 2.0 and implemented control enhancements in NSF systems to further mitigate data quality risks, improve reporting workflow, and minimize reliance on manual processes. NSF also conducted independent testing of its "higher risk" data elements and operational key controls over DATA Act reporting. This testing confirmed that NSF's controls were designed and are operating effectively to meet the reporting objectives of submitting complete, accurate, and timely data to USASpending.gov.

*Pay and Allowance System for Civilian Employees, provided primarily in Chapters 31–50 of Title 5, U.S.C.*: The Department of the Interior, Interior Business Center (IBC) Federal Personnel/Payroll System (FPPS) is a Shared Service Provider and performs many of NSF's payroll functions. IBC FPPS's internal control is reviewed annually by auditors under SSAE 18. IBC's FPPS controls were found to be suitably designed and operating effectively for FY 2020; this conclusion is based partly on transactional testing. In addition, NSF verified that its complementary user entity controls for FPPS provided adequate coverage for responsible reliance on IBC's payroll services.

*Prompt Payment Act*:  The Prompt Payment Act mandates interest penalties on payments over 30 days. Under OMB M-17-27, *Reducing Burden for Federal Agencies by Rescinding and Modifying OMB Memoranda*, NSF encourages accelerating payments to all contractors within 15 days of a proper invoice being received. This acceleration allows small business contractors to be paid as quickly as possible.

*Government Charge Card Abuse Prevention Act of 2012, Pub. L. 112 – 194:* The act requires that agencies ensure that appropriate policies and controls are in place or that corrective actions have been taken to mitigate the risk of fraud and inappropriate charge card practices. NSF provides reasonable assurance that internal controls related to the government charge card programs are operating effectively, and no material weaknesses were identified. Additional information is provided above in subsection *Improving the Management of Government Charge Card Programs—OMB Circular A-123, Appendix B*, page MD&A-31.

*Provisions Governing Claims of the U.S. Government (31 U.S.C. 3711–3720E) (Including the Debt Collection Improvement Act of 1996)*: The Debt Collection Improvement Act is addressed on page MD&A-27.

*Federal Information Security Modernization Act of 2014*: This topic is addressed above in subsection *Compliance with the Federal Financial Management Improvement Act of 1996—OMB Circular A-123, Appendix D*, page MD&A-31.

*Single Audit Act of 1984, Pub L. No. 98-502, and the Single Audit Act Amendments of 1996, P.L. 104-156. (A-136, section II.2.8)*: In accordance with 2 CFR § 200.501, Subpart F, Audit Requirements, non-federal entities that expend $750,000 or more during the non-federal entity's fiscal year in federal awards must have a single or program specific audit conducted for that year. Federal agency internal control standards determine whether award expenditures comply with laws and regulations. NSF, like other federal agencies, is required to review the findings and recommendations of audit reports for funding recipients to determine whether corrective actions (if required) are adequate and implemented. NSF utilizes guidance from the OMB Uniform Administrative Requirements, Cost Principles, and Audit Requirements for Federal Awards (Uniform Guidance) and Audit Follow-up as a basis for its audit resolution and follow-up activities. During FY 2020, NSF resolved 143 single audit reports.

*Fraud Reduction and Data Analytics Act of 2015 (FRDAA), P.L. 114-186:* In FY 2020, NSF incorporated fraud risk into its analytics and control monitoring activities to proactively identify and mitigate potential fraud scenarios. Areas where NSF implemented a fraud risk-based approach include the improper payments predictive model, travel card misuse dashboard, and enhanced risk and control checkpoints described in the preceding section.

## Financial System Strategy and Framework

### Financial System Strategy
iTRAK is NSF's Oracle-based commercial-off-the-shelf financial system, hosted in the 'cloud' by a commercial provider. iTRAK provides automated business processes, funds management, and reporting capabilities for NSF's external and internal customers, including grantees, financial and administrative staff, and program managers. NSF's financial system also performs system edit checks and provides an audit trail for financial transactions, thereby strengthening internal controls. iTRAK aligns with NSF's strategic objective to continually improve agency operations by enabling efficient, effective execution of financial activities and business operations; and it supports the agency in its stewardship role by providing managers and staff with financial data and reports, so they may make informed decisions about the programs they manage and support. For example, an iTRAK Open Obligations Reporting Tool was developed to assist NSF staff with prioritizing the review of open obligations and understanding the related funding impacts. The reporting tool supports NSF's efforts to continuously employ sound financial management and stewardship funding practices to fully utilize resources.

iTRAK complies with federal mandates and regulations by ensuring that transactions are posted in accordance with the U.S. Standard General Ledger (USSGL) at the transaction level; maintaining

accounting data to permit reporting in accordance with Generally Accepted Accounting Principles, as prescribed by the Federal Accounting Standards Advisory Board. iTRAK also complies with OMB Circular A-130, "Managing Federal Information as a Strategic Resource," OMB Circular A-123, Appendix D, "Compliance with the Federal Financial Management Improvement Act of 1996," and other federal regulations and guidance such as the CFO Act, FISMA, and the Rehabilitation Act, Section 508.

In April 2020, OMB issued Memorandum M-20-21, *Implementation Guidance for Supplemental Funding Provided in Response to the Coronavirus Disease 2019 (COVID-19)*. This memorandum significantly changed the reporting landscape for the DATA Act, through the issuance of new reporting requirements from the Department of Treasury in May 2020. After reaching a steady state of operations with DATA Act reporting, these new OMB and Treasury requirements shifted NSF back into an implementation phase. This required changes to NSF systems, processes, and controls, with many coordination points and moving parts across these three domains. NSF volunteered to be an early tester of Oracle's new DATA Act functionality for iTRAK, and in the process, identified several changes to the new functionality that would benefit NSF and the government-wide community. As one of the earliest agencies ready to report under the new requirements, NSF was also able to test early with the Department of Treasury, allowing them to test their processes and new visualizations for COVID-19. The entire initiative had an aggressive timeline, with a limited testing window for agencies to validate their data with Treasury, and three monthly submissions all due within the same 10-day reporting window. NSF successfully attested to and published its first DATA Act submissions for April, May, and June under the new requirements two days earlier than the legislative deadline of July 30, 2020.

In April 2019, OMB issued M-19-16, *Centralized Mission Support Capabilities for the Federal Government.* The objective of this guidance is to develop a new approach to shared services that will reduce duplication, improve accountability, and improve federal shared services. This initiative is one of the focus areas of the President's Management Agenda that centers on the Sharing Quality Services Cross Agency Priority Goal and improvements to government mission-support services. Under this initiative, Treasury was designated as the Financial Management Quality Service Management Office (FM QSMO) to establish a marketplace of systems and services that drive innovation, compliance with federal policies, standardization, and automation. In alignment with this goal, during FY 2020, NSF continued to work closely with Treasury's FM QSMO to identify services that may benefit NSF in meeting NSF's financial management and mission objectives.

In FY 2020, an independent accounting firm examined iTRAK's IT controls. The assessment was favorable with no significant findings. Details about the review are on page MD&A-28 in the subsection, *Compliance with the Federal Financial Management Improvement Act of 1996–OMB Circular A-123, Appendix D.*

As iTRAK continues to mature, NSF will continue to expand its analytical capabilities toward a more performance-driven system through reporting and data analytics tools and dashboards to better support NSF's mission. In keeping with this objective, NSF will continue to explore opportunities for iTRAK reporting and integration enhancements. Future initiatives on the horizon are summarized as follows with anticipated implementation dates:

- General Services Administration's (GSA's) System for Award Management (SAM) Unique Entity Identification (UEI) (FY 2021)——NSF will implement GSA's UEI requirements in place of the DUNS number as the primary key for institutions/vendors doing business with the federal government. This requires enhancements to iTRAK and certain NSF business applications.

- DATA Act DAIMS 2.0 (FY 2021 and FY 2022) – NSF will implement the requirement to report the Program Activity code in the appropriate file (File C) starting in FY 2021. Additionally, NSF will continue preparing for the DAIMS 2.0 requirement to report outlays for all transactions in File C starting in FY 2022.

- G-Invoicing (FY 2023)—NSF will integrate with Treasury's new G-invoicing system which will serve as the front-end application for users to originate and manage interagency agreements.

### *Financial Management System Framework*

NSF's financial management system framework focuses on the Foundation's financial management systems, standard business processes, data, and information architecture to ensure reliable, timely, and consistent financial information that enables effective management of NSF resources and delivery of mission critical products and services (see Figure 1.9).

NSF's core financial system, iTRAK, interfaces with NSF's awards, grants management, and business process systems including:

- ACM$;

- Award Management and Award Letter System ("Awards");

- eJacket, NSF's internal awards processing system;

- Research.gov and FastLane, NSF's websites through which researchers, research administrators and their organizations, and reviewers interact with NSF;

- GRFP system; and

- Guest Travel and Reimbursement System.

iTRAK also interfaces with external systems operated by Treasury; Citibank and LearnNSF, the Foundation's training system; and with other federal systems such as FPPS, eTravel/Concur, and GSA's SAM.

**Figure 1.9—NSF Financial Management System Framework**