NETWORKING AND INFORMATION TECHNOLOGY RESEARCH AND DEVELOPMENT (NITRD)

Total Funding for NITRD
(Dollars in Millions)

	FY 2018 Actual	FY 2019 (TBD)	FY 2020 Request
BIO	$93.50	-	$79.00
CISE	960.80	-	883.04
EHR	9.50	-	9.50
ENG	32.59	-	33.35
GEO	24.00	-	20.00
MPS	152.34	-	149.47
SBE	22.84	-	22.97
Total	**$1,295.57**	**-**	**$1,197.33**

Overview

NSF is a primary supporter of the NITRD program, and NSF's NITRD portfolio includes all research, research infrastructure, and education investments in CISE, as well as contributions from all other directorates across the agency, enabling investments in every NITRD Program Component Area (PCA). The NSF assistant director for CISE is co-chair of the NITRD Subcommittee of the National Science and Technology Council's Committee on the Science and Technology Enterprise. In addition, numerous NSF staff work in close collaboration with other NITRD agencies and participate in all NITRD Interagency Working Groups, including at the co-chair level in most.

NSF's FY 2020 Budget Request includes support for NITRD at a level of $1,197.33 million. NITRD activities represent approximately 17 percent of NSF's FY 2020 Budget Request to Congress. CISE's support comprises 74 percent of NSF's NITRD activities.

The PCAs are reviewed annually to ensure they remain relevant and reflect the most up-to-date R&D needs of the Nation. For FY 2020, the Artificial Intelligence (AI) R&D PCA was added to support the Administration's goal of being a world leader in the development of transformative AI technologies. AI-related programs that have primary emphases other than AI are reported in other PCAs. The definition of the Computing-Enabled Human Interaction, Communication, and Augmentation (CHuman) PCA was updated to remove overlaps with the new AI PCA and to focus on group and collaborative systems, tools, and studies rather than on individuals. The definition of the Software Productivity, Sustainability, and Quality (SPSQ) PCA was updated to better reflect the current state of software research.

FY 2020 NSF Investments by Program Component Area (PCA)

The following information focuses on FY 2020 NSF investments, both new and continuing, by PCA.

AI R&D ($193.88 million): A key focal point of the increased investment in AI R&D will be support for *AI Frontiers*, a new center-scale activity that will span (a) foundational areas of machine learning (ML), computer vision, natural language processing, and autonomy, along with safety, security, robustness, and explainability of AI systems; (b) translational research at the intersection of AI and various science and engineering domains supported by NSF as well as sectors such as agriculture, transportation, and personalized medicine; (c) workforce development, including growing human capital and institutional

capacity to nurture a next generation of AI researchers and practitioners; and (d) advanced computing infrastructure, including access to data and compute capabilities enabling AI innovations.

AI will also support HDR through research investments in real-time sensing, learning, and decision making. Additionally, it will include ENG investments in advanced manufacturing and the mind, machine, and motor nexus; SBE investments to integrate machine learning advances with learning mechanisms developed in cognitive science, develop new statistical inferences and algorithms for the analysis of large data sets, and understand the legal and ethical implications of AI; BIO investments in ML, natural language processing, computer vision, and genetic algorithms applied to solve problems such as genome sequence alignment, prediction of protein structure, reconstruction of evolutionary relationships, and extraction of quantitative information from multi-media data sources; and MPS investments in ML, deep learning, and neural networks through the Condensed Matter and Materials Theory, Designing Materials to Revolutionize and Engineer our Future, and Materials Research Science and Engineering Centers programs.

CHuman ($77.16 million): CHuman will include investment in FW-HTF, which supports convergent research to understand and develop the human-technology partnership, design new technologies to augment human performance, illuminate the emerging socio-technological landscape, and foster lifelong and pervasive learning with technology. As part of FW-HTF, CHuman will also include investment in the Cyberlearning for Work at the Human-Technology Frontier program, which will respond to the pressing societal need to educate and re-educate learners of all ages (American students, teachers, and workers) in STEM content areas so that they are equipped with the skills required for future jobs. CHuman will also include SBE investment on cyberinfrastructure related to its three major ongoing social science surveys (American National Election Studies, the Panel Study of Income Dynamics, and the General Social Survey), which will enable examination of societal concerns, such as competitiveness, security, economic development, and well-being.

Computing-Enabled Networked Physical Systems (CNPS) ($62.35 million): CNPS will include CISE and ENG investments in Cyber-Physical Systems (CPS), enabling foundational interdisciplinary research and education in adaptive and pervasive smart systems supporting applications such as the smart grid, intelligent transportation systems, and medical devices. It will also include investment in the NSF-wide Smart and Connected Communities (S&CC) program, which will support interdisciplinary, integrative research that deeply engages local residents, stakeholders, and governments to improve understanding, design, and long-term sustainability of intelligent infrastructure for American communities, thereby leading to enhanced quality of life for residents. CNPS will additionally include BIO investment in expanding and enhancing access to the national resource of digital biological and paleontological data and ENG investment in advanced manufacturing, including cyber-manufacturing.

Cyber Security and Privacy (CSP) ($96.20 million): CSP will include investment in the NSF-wide SaTC program and other related cybersecurity and privacy research. The investment in SaTC in particular will support foundational research necessary to ensure society's ubiquitous computing and communication systems are resistant to cyber-attacks and associated vulnerabilities, while enabling and preserving privacy and trust.

Education and Workforce (EdW) ($55.70 million): EdW will include CISE and EHR investments in IUSE: Computing in Undergraduate Education (CUE), to support efforts to re-envision the role of computing in interdisciplinary collaboration within American institutions of higher education and in Computer Science for All: Researcher-Practitioner Partnerships (CSforAll: RPPs), to support the R&D needed to bring computer science and computational thinking to all schools at the preK-12 levels. It will also include CISE and EHR investments supporting workforce development in cybersecurity, enabling a growing pipeline of researchers, educators, and practitioners, and allowing all Americans to understand the security and privacy of the digital systems on which their lives increasingly depend. EdW will additionally include BIO

investment in advancing America's ability to incorporate and apply biological knowledge to economic development and other issues of societal importance.

Enabling-R&D for High-Capability Computing Systems (EHCS) ($159.30 million): EHCS will include investments in strategic computing activities previously initiated under the National Strategic Computing Initiative, which will support research advances in new computing technologies, architectures, and platforms for the future, as well as the development of advanced computing systems and services, including maximizing the benefits of these systems and services through deep integration with science and engineering research. EHCS will also include MPS investment that advances computational algorithms and data analytics to address scientific and engineering challenges presented by data emerging from digital and observational data sources. It will also include MPS investment in fundamental research on innovative materials integration and novel phenomena associated with quantum information science, optical computing, and neuro-computing.

High-Capability Computing Infrastructure and Applications (HCIA) ($160.50 million): HCIA will include CISE investments on the development of software and algorithms for advanced computing systems and services. For example, HCIA will include CISE and MPS investments in new computational methods, algorithms, scientific databases, and other computational tools to support researchers in the mathematical and physical sciences as well as engineering through programs such as Computational and Data-Enabled Science and Engineering; CISE and GEO investment in EarthCube, a cyberinfrastructure investment for the geosciences; GEO investment in the operations and maintenance of the National Center for Atmospheric Research's Wyoming Supercomputer facility and associated modeling efforts; and BIO investment in the application of advanced computing to a range of grand challenge problems in the biological sciences, including UtB, the genotype-to-phenotype relationship, and the environmental sciences.

Intelligent Robotics and Autonomous Systems (IRAS) ($36.01 million): IRAS will include CISE and ENG investments in robotics and autonomous systems, including research related to the design, application, and use of robotics to augment human function, promote human-robot interaction, and increase robot autonomy. As part of the next generation of robotics, co-robot systems will be characterized by their flexibility and resourcefulness. They will use a variety of modeling or reasoning approaches, along with real-time, real-world data, demonstrating a level of intelligence and adaptability seen in humans and animals. As development of this next generation of robotics proceeds, complete confidence in the robotic systems that work beside, or cooperatively with, people in application domains such as advanced manufacturing, emergency response, and health care becomes increasingly important.

Large-Scale Data Management and Analysis (LSDMA) ($173.36 million): LSDMA will include investment in HDR, including foundational research in data science and engineering; the development of a cohesive, federated approach to the research data infrastructure; and development of a 21st-century data-capable workforce. As part of HDR, LSDMA will include investment in the development of a comprehensive, scalable data infrastructure via the NSF-wide Cyberinfrastructure for Sustained Scientific Innovation (CSSI) program and the Computational and Data-Enabled Science and Engineering (CDS&E) program.

LSDMA will also include ENG investment on cyberinfrastructure for the Natural Hazards Engineering Research Infrastructure, which provides access to and storage and analysis of massive amounts of data related to natural disasters; MPS investments in Data-Driven Discovery Science in Chemistry as well as Computational Mathematics; SBE investments in data science and associated research infrastructure; and BIO investment in integrative modeling of complex biological processes.

Large-Scale Networking (LSN) ($117.25 million): LSN will include CISE investment on a set of Platforms for Advanced Wireless Research that enable research on topics ranging from dynamic spectrum sharing to

measurement and monitoring, thus advancing the next generation of high-performance, robust wireless networks. LSN will also include a portion of CISE's investment in the NSF-wide S&CC program.

SPSQ ($65.62 million): SPSQ will include investment in the software foundations within CISE, as well as new thinking, paradigms, and practices in developing and using software that is robust, reliable, usable, and sustainable through the NSF-wide CSSI program. SPSQ will also include investment in NSF-wide programs, such as the interagency and international Collaborative Research in Computational Neuroscience (CRCNS). For example, through CRCNS, BIO will fund research involving the development of software and other computational tools to advance biological knowledge and computational innovations.

NITRD Funding by Program Component Area
(Dollars in Millions)

	FY 2018 Actual	FY 2019 (TBD)	FY 2020 Request
Artificial Intelligence R&D	$184.51	-	$193.88
Computing-Enabled Human Interaction, Communications, Augmentation	104.85	-	77.16
Computing-Enabled Networked Physical Systems	67.72	-	62.35
Cyber Security and Privacy	103.99	-	96.20
Education and Workforce	75.51	-	55.70
Enabling-R&D for High-Capability Computing Systems	178.17	-	159.30
High Capability Computing Infrastructure and Applications	177.84	-	160.50
Intelligent Robotics and Autonomous Systems	38.21	-	36.01
Large-Scale Data Management and Analysis	167.16	-	173.36
Large Scale Networking	128.05	-	117.25
Software Productivity, Sustainability and Quality	69.56	-	65.62
Total	**$1,295.57**	**-**	**$1,197.33**