NETWORKING AND INFORMATION TECHNOLOGY RESEARCH AND DEVELOPMENT (NITRD)

Total Funding for NITRD
(Dollars in Millions)

	FY 2019 Actual	FY 2020 (TBD)	FY 2021 Request
BIO	$77.00	-	$90.00
CISE	980.32	-	1,062.40
EHR	9.90	-	9.50
ENG	129.45	-	142.37
GEO	20.00	-	19.00
MPS	173.71	-	213.39
SBE	26.56	-	31.67
Total	**$1,416.94**	**-**	**$1,568.33**

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 (NSTC) 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 also facilitates interaction between NITRD and other bodies of the NSTC as appropriate. For example, the NSF assistant director for CISE also co-chairs the Machine Learning and Artificial Intelligence (MLAI) Subcommittee, enabling close coordination between NITRD and MLAI.

NSF's FY 2021 Budget Request includes support for NITRD at a level of $1,551.33 million. NITRD activities represent approximately 20 percent of NSF's FY 2021 Budget Request to Congress. CISE's support comprises 68 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. No major changes were made to the PCAs for FY 2021.

FY 2021 NSF Investments by Program Component Area (PCA)

The following information focuses on FY 2021 NSF investments, both new and continuing, by PCA.

AI R&D ($425.11 million): AI R&D will include investments in fundamental research advancing AI. A key focal point of the increased investment in AI R&D will be support for National AI Research Institutes. These center-scale projects will advance foundational research; leverage use-inspired research; build the next-generation of talent; mobilize multidisciplinary groups of scientists, engineers, and educators; and serve as a nexus point for multisector collaborative efforts. The National AI Research Institutes will fill a critical gap in America's AI research and education portfolio by accelerating AI innovations, training AI researchers and innovators, and transitioning outcomes across a range of sectors.

AI R&D will also include increased investments in HDR and FW-HTF stewardship funds that will allow NSF to fund critical new methods and advances in AI, notably in deep learning and machine learning (ML),

as well as the evolving symbiosis of humans and AI in work.

Additionally, this PCA will include CISE investments in foundational research in AI, including knowledge representation and reasoning, multi-agent systems, planning, machine and deep learning, computer vision, and human language technologies; 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, extraction of quantitative information from multi-media data sources, and the bioeconomy more generally; 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.

Computing-Enabled Human Interaction, Communications, Augmentation (CHuman) ($92.37 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 program, which will support educating and re-educating learners of all ages and career stages (American students, teachers, and workers) in STEM content areas through emerging technologies. 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 American competitiveness, security, economic development, and well-being.

Computing-Enabled Networked Physical Systems (CNPS) ($82.89 million): CNPS will include CISE and ENG investments in Cyber-Physical Systems, 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 and future manufacturing, including cyber-manufacturing.

Cyber Security and Privacy (CSP) ($106.24 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. SaTC emphases will span AI and ML, including adversarial ML; implications of quantum computing for security, including post-quantum cryptography; architectures and technologies for protecting cyberspace from increasingly sophisticated connected devices; and security and privacy aspects of smart infrastructure including the Internet of Things.

Education and Workforce (EdW) ($61.03 million): EdW will include CISE and EHR investments in IUSE: Computing in Undergraduate Education, 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, 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) ($162.96 million): EHCS will include investments in strategic computing activities initiated under the recently updated National Strategic Computing Initiative,[1] 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 CISE and MPS investments that advance computational algorithms and data analytics to address scientific and engineering opportunities presented by data emerging from digital and observational data sources. It will also include CISE and MPS investments 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) ($170.36 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 the genotype-to-phenotype relationship, and the environmental sciences.

Intelligent Robotics and Autonomous Systems (IRAS) ($57.58 million): IRAS will include CISE and ENG investments in robotics and autonomous systems that exhibit significant levels of both computational capability and physical complexity, 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, collaborative robotics (co-robot) systems, i.e., robotic systems that work beside or cooperatively with people, 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 co-robotics proceeds in application domains such as advanced manufacturing, emergency response, and health care, complete confidence in these systems becomes increasingly important.

Large-Scale Data Management and Analysis (LSDMA) ($213.85 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 CISE investments in the development of a comprehensive, scalable data infrastructure. LSDMA will additionally 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.

[1] www.whitehouse.gov/wp-content/uploads/2019/11/National-Strategic-Computing-Initiative-Update-2019.pdf

Large-Scale Networking (LSN) ($131.0 million): LSN will include CISE investment in the NSF-wide S&CC program as well as 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 NSF investment in the Spectrum Innovation Initiative supporting foundational spectrum research in increased spectrum efficiencies, flexibility, and adaptability and leading to the creation of advanced wireless technologies and systems beyond 5G.

Software Productivity, Sustainability and Quality (SPSQ) ($64.94 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 Cyberinfrastructure for Sustained Scientific Innovation (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 2019 Actual	FY 2020 (TBD)	FY 2021 Request
Artificial Intelligence R&D	$234.96	-	$425.11
Computing-Enabled Human Interaction, Communications, Augmentation	94.63	-	92.37
Computing-Enabled Networked Physical Systems	77.09	-	82.89
Cyber Security and Privacy	110.26	-	106.24
Education and Workforce	81.51	-	61.03
Enabling-R&D for High-Capability Computing Systems	178.77	-	162.96
High Capability Computing Infrastructure and Applications	196.17	-	170.36
Intelligent Robotics and Autonomous Systems	45.89	-	57.58
Large-Scale Data Management and Analysis	194.24	-	213.85
Large Scale Networking	131.31	-	131.00
Software Productivity, Sustainability and Quality	72.11	-	64.94
Total	**$1,416.94**	**-**	**$1,568.33**