NETWORKING AND INFORMATION TECHNOLOGY RESEARCH AND DEVELOPMENT (NITRD)

Networking and Information Technology Research and Development Funding[1]

(Dollars in Millions)

	FY 2022 Actual[2]	FY 2023 Estimate Base	Disaster Relief Supplemental		FY 2023 Estimate Total	FY 2024 Request
			Base	CHIPS and Science		
BIO	$79.00	$79.00	-	-	$79.00	$81.50
CISE	1,015.57	1,010.57	40.00	-	1,050.57	1,172.14
EDU	17.65	22.09	-	-	22.09	22.09
ENG	167.42	156.45	-	-	156.45	179.26
GEO Programs	23.00	27.00	-	-	27.00	30.00
MPS	345.76	224.15	-	-	224.15	239.34
SBE	41.89	30.94	2.00	-	32.94	38.94
TIP	224.10	196.13	95.91	91.53	383.57	516.76
IA	14.30	1.00	-	-	1.00	1.00
Total	**$1,928.69**	**$1,747.33**	**$137.91**	**$91.53**	**$1,976.77**	**$2,281.03**

[1] Funding displayed may have overlap with other topics and programs.

[2] FY 2022 Actuals may be greater than future fiscal years due to the receipt of more meritorious proposals than expected.

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. NSF leadership also co-chair the Machine Learning and Artificial Intelligence (MLAI) as well as the Future Advanced Computing Ecosystem (FACE) Subcommittees, enabling close coordination between NITRD, MLAI, and FACE.

Through NITRD, NSF coordinates its investments in networking and information technology research and development across more than 20 federal departments, agencies, and offices. 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. As noted above, NSF also facilitates interaction between NITRD and other bodies of the NSTC as appropriate.

FY 2024 NITRD Funding

NSF's FY 2024 Budget Request includes support for NITRD at a level of $2,281.03 million. NITRD activities represent approximately 20.2 percent of NSF's FY 2024 Budget Request to Congress.

Investments by Program Component Area (PCA)

The PCAs are reviewed annually to ensure they remain relevant and reflect the most up-to-date R&D needs of the Nation.
The following information focuses on FY 2024 NSF investments, both new and continuing, by PCA.

NITRD Funding by Program Component Area

(Dollars in Millions)

			Disaster Relief Supplemental			
	FY 2022 Actual[1]	FY 2023 Estimate Base	Base	CHIPS and Science	FY 2023 Estimate Total	FY 2024 Request
Advanced Communication Networks and Systems (ACNS)	$212.62	$197.23	$7.64	$7.29	$212.16	$237.53
Artificial Intelligence R&D (AI)	506.53	391.78	26.64	24.48	442.90	531.34
Computing-Enabled Human Interaction, Comm. Aug. (CHuman)	111.05	89.65	1.18	1.13	91.96	108.88
Computing-Enabled Networked Physical Systems (CNPS)	82.91	107.20	16.34	15.59	139.13	166.56
Cyber Security and Privacy (CSP)	120.04	108.58	9.25	3.58	121.41	134.25
Education and Workforce (EdW)	95.64	102.97	12.53	6.71	122.21	143.12
Enabling-R&D for High-Capability Computing Systems (EHCS)	179.96	165.62	0.17	0.16	165.95	186.33
Electronics for Networking and Information Technology (ENIT)	72.79	78.29	11.31	10.79	100.39	119.11
High Capability Computing Infrastructure and Applications (HCIA)	209.57	178.79	30.61	0.58	209.98	228.86
Intelligent Robotics and Autonomous Systems (IRAS)	48.14	48.98	4.77	4.55	58.30	69.91
Large-Scale Data Management and Analysis (LSDMA)	222.15	206.83	14.45	13.79	235.07	265.35
Software Productivity, Sustainability, and Quality (SPSQ)	67.30	71.41	3.02	2.88	77.31	89.79
Total	**$1,928.69**	**$1,747.33**	**$137.91**	**$91.53**	**$1,976.77**	**$2,281.03**

[1] FY 2022 Actuals may be greater than future fiscal years due to the receipt of more meritorious proposals than expected.

Advanced Communication Networks and Systems (ACNS)

ACNS will include CISE investments in the NSF-wide Smart and Connected Communities (S&CC) program. ACNS will also include NSF investments in the Spectrum Innovation Initiative supporting fundamental spectrum research in increased spectrum efficiencies, flexibility, and adaptability and leading to the creation of advanced wireless technologies and systems beyond 5G. Additionally, in collaboration with other federal agencies and the private sector, ACNS will include NSF investments on Resilient and Intelligent Next-Generation (NextG) Systems (RINGS), transforming emerging NextG wireless and mobile communication, networking, sensing, and computing. Finally, ANCS will include NSF investments in federating an open-access plane across the four Platforms for Advanced Wireless Research, creating an interconnected national network for testing and validation of emerging wireless concepts ranging from dynamic spectrum sharing to measurement and monitoring.

AI R&D

AI R&D will include investments in fundamental research advancing AI. A key focal point of 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 major 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. In addition, through the Expanding AI Innovation through Capacity Building and Partnerships (ExpandAI) program NSF will significantly broaden participation in AI research, education, and workforce development through capacity

development projects and through partnerships within the National AI Research Institutes ecosystem.

AI R&D will also include the initial steps toward implementation of the recommendations of the National AI Research Resource (NAIRR) Task Force, a Congressionally chartered Federal Advisory Committee charged with developing a roadmap and implementation plan for a shared computing and data infrastructure that would provide the Nation's AI researchers and students with access to a holistic ecosystem of resources to fuel AI discovery and innovation.

This PCA also includes 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; EDU investments in AI-enabled teaching and learning systems; 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; 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; and TIP investments in Regional Innovation Engines, which leverage multiple disciplines, institutions, and sectors to advance emerging technologies, including AI, and address major societal and economic challenges in areas such as the bioeconomy and climate change.

Computing-Enabled Human Interaction, Communications, Augmentation (CHuman)

CHuman will include investments to 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 investments in the Smart Health and Biomedical Research in the Era of AI and Advanced Data Science program, which will support the development of transformative high-risk, high-reward advances in computer and information science, engineering, mathematics, statistics, behavioral and/or cognitive research to address pressing questions in the biomedical and public health communities. In addition, CHuman will include SBE investments 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)

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 investments in the NSF-wide 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 also includes TIP investments in the Convergence Accelerator (CA) which accelerates use-inspired, solutions-oriented research and piloting in specific areas of national importance; in FY 2023, the CA will launch a regional

approach supporting regional cohorts pursuing location-specific challenges in agriculture, energy, and transportation, to name a few. CNPS will additionally include BIO investments in expanding and enhancing access to the national resource of digital biological and paleontological data and ENG investments in advanced and future manufacturing, including cyber-manufacturing.

Cyber Security and Privacy (CSP)

CSP will include investments in the NSF-wide SaTC program and other related cybersecurity and privacy research. The investments 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. In addition, CSP includes investments to transition research to practice, such as approaches to harden privacy-enhancing technologies led by TIP in collaboration with CISE and SBE. CSP also includes NSF investments in programs that strengthen pathways for the national cybersecurity workforce, including support for innovation at the K-12 level, community colleges, and four-year universities.

Education and Workforce (EdW)

EdW will include collaboration between CISE and EDU on investments across all education levels, including at the undergraduate level through IUSE: Computing in Undergraduate Education, which supports efforts to re-envision the role of computing in interdisciplinary collaboration within American institutions of higher education. CISE and EDU will also invest at the K-12 levels through Computer Science for All: Researcher-Practitioner Partnerships, which supports the R&D needed to bring computer science and computational thinking to all schools at the preK-12 levels. CISE and EDU will also support workforce development in cybersecurity, enabling a growing cadre 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. As part of this investment, EdW will fund programs in CISE and EDU that strengthen pathways for the national cybersecurity workforce, including support for innovation at the K-12 level, in community colleges, and at four-year universities. EdW will additionally include BIO investments in advancing America's ability to incorporate and apply biological knowledge to economic development and other issues of societal importance, and TIP investments that offer experiential and entrepreneurial opportunities to students and researchers at all levels pursuing studies in emerging technologies. In general, EdW investments will continue to promote equity through a broad suite of activities that support broadening participation in STEM research and education, and that study the causes of, impacts on, and practices for addressing inequity in STEM participation.

Enabling-R&D for High-Capability Computing Systems (EHCS)

In alignment with the FACE Strategic Plan[1], EHCS will include investments which support (i) research advances in new computing technologies, architectures, and platforms for the future; (ii) the development and deployment of advanced computing systems and services, while maximizing the benefits of these systems and services through deep integration with science and engineering research; and (iii) formulation of approaches for the federation of advanced computing systems and

[1] www.nitrd.gov/pubs/Future-Advanced-Computing-Ecosystem-Strategic-Plan-Nov-2020.pdf

services to realize a National Discovery Cloud for Climate (NDC-C). 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.

Electronics for Networking and Information Technology (ENIT)
ENIT will include CISE, ENG, and MPS investments in biological computation, nanoscale science and engineering, quantum information science and engineering, and neuromorphic computing as well as other disruptive technologies. ENIT will also include CISE, ENG, and MPS investments in the underlying fundamental physical and materials science; design and design automation of electronic devices, circuits, and systems, systems architectures, and related software; and the fabrication and characterization of tools and facilities required for advanced microelectronics and semiconductor technologies. In addition, in collaboration with private industry, ENIT will include CISE, ENG, MPS, and TIP investments that advance research on the design and manufacture of future semiconductor technologies.

High Capability Computing Infrastructure and Applications (HCIA)
HCIA will include CISE investments on the development and deployment of software and algorithms for advanced computing systems and services. HCIA will include CISE investments in the NDC-C that will federate access to compute resources from multiple sources, including NSF-funded advanced computing resources, edge resources located at NSF major facilities, and at other compute- and data-intensive NSF research facilities, as well as commercial cloud computing resources. These investments will also build on 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 investments in advanced cyberinfrastructure for the geosciences; GEO investments in the operations and maintenance of the National Center for Atmospheric Research's Wyoming Supercomputer facility and associated modeling efforts; and BIO investments 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. HCIA investments will further understanding of climate science and clean-energy technologies by enabling data science, artificial intelligence and machine learning, and predictive and high-end computational modeling and simulation. HCIA will also include initial steps toward implementation of the recommendations of the NAIRR Task Force.

Intelligent Robotics and Autonomous Systems (IRAS)
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)

LSDMA will include CISE investments in the development of a comprehensive, scalable data infrastructure, as well as CISE investments in the NDC-C that will incorporate systems to curate, federate, and provide access to data from multiple sources, be they NSF-funded large facilities, resources from industry/non-profits, or the data contribution of individual researchers, to enable new scientific discoveries by supporting the broad examination and reexamination of collected data, and the scientific analysis of combinations of heterogeneous data. LSDMA will additionally include ENG investments in 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 investments in integrative modeling of complex biological processes.

Software Productivity, Sustainability and Quality (SPSQ)

SPSQ will include investments 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 include CISE investments in the NDC-C that will democratize access to advanced compute, data, software, and networking resources. SPSQ will also include investments 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.