



The Networking & Information Technology R&D Program
and the
National Artificial Intelligence Initiative Office

SUPPLEMENT TO THE PRESIDENT'S FY 2024 BUDGET

A report by the
SUBCOMMITTEE ON NETWORKING & INFORMATION TECHNOLOGY
RESEARCH & DEVELOPMENT
and the
MACHINE LEARNING & ARTIFICIAL INTELLIGENCE SUBCOMMITTEE
of the
NATIONAL SCIENCE & TECHNOLOGY COUNCIL

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About the Subcommittee on Networking & Information Technology Research & Development

The Networking and Information Technology Research and Development (NITRD) Program has been the Nation's primary source of federally funded work on pioneering information technologies (IT) in computing, networking, and software since it was first established as the High-Performance Computing and Communications program following passage of the High-Performance Computing Act of 1991. The NITRD Subcommittee of the NSTC guides the multiagency NITRD Program in its work to provide the R&D foundations for ensuring continued U.S. technological leadership and for meeting the Nation's needs for advanced IT. The National Coordination Office (NCO) supports the NITRD Subcommittee and its Interagency Working Groups (IWGs) (<https://www.nitrd.gov/about/>).

About This Document

This document is a supplement to the President's FY 2024 Budget Request to Congress. Following Congressional mandate, the Supplement incorporates budgetary and programmatic information for member agencies of the NITRD Program and for the National Artificial Intelligence Initiative. This report covers FY 2022 actual, FY 2023 enacted, and FY 2024 requested funding levels by agency and Program Component Area for NITRD R&D programs. It also describes the key R&D programs and coordination activities planned for FY 2024 by the Federal agencies participating in NITRD. This Supplement reports specific agency investments for FYs 2022–2024 for AI and the National AI Research Institutes and for advanced wireless communications. A separate appendix, the FY 2024 *Federal Cybersecurity R&D Strategic Plan Implementation Roadmap*, lists existing and proposed R&D projects that address critical national cybersecurity needs (<https://www.nitrd.gov/pubs/FY2024-Cybersecurity-RD-Roadmap.pdf>).

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Department of Homeland Security

Cybersecurity and Infrastructure Security Agency (CISA)

Department of Justice (DOJ)

Federal Bureau of Investigation (FBI)

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Occupational Safety & Health Administration (OSHA)

Department of Transportation (DOT)

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 Federal Highway Administration (FHWA)
 Federal Motor Carrier Safety Administration (FMCSA)
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 Maritime Administration (MARAD)
 National Highway Traffic Safety Administration (NHTSA)

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Environmental Protection Agency (EPA)

Federal Communications Commission (FCC)

Federal Trade Commission (FTC)

General Services Administration (GSA)

Office of Director of National Intelligence (ODNI)

Intelligence Advanced Research Projects Activity (IARPA)
 National Maritime Intelligence-Integration Office (NMIO)

National Archives and Records Administration (NARA)

National Transportation Safety Board (NTSB)

Nuclear Regulatory Commission (NRC)

U.S. Agency for Global Media (USAGM)

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1.0 Introduction

Federal funding for networking and information technology research and development (R&D) is essential to maximize the benefits of science and technology that advance health, tackle the climate crisis, and bring prosperity, security, environmental quality, and justice for all Americans. This Supplement to the President's FY 2024 Budget provides an overview of the Networking and Information Technology Research and Development (NITRD) Program's \$10.9 billion FY 2024 R&D budget request, a 13.5% increase over the FY 2023 budget request, and including a 19.2% increase in artificial intelligence R&D investments. With these increases, NITRD agencies are answering the Biden-Harris Administration call to focus activities, programs, and investments in all seven domains identified in the FY 2024 Multi-Agency Research and Development Priorities memo.¹ Throughout the Supplement there are highlighted example programs that advance solutions within these seven domains: Preparing for and preventing pandemics; Reducing the death rate from cancer by half; Tackling climate change; Advancing national security and technological competitiveness; Innovating for equity; Cultivating an equitable STEM education, engagement, and workforce ecosystem; Promoting open science and community-engaged R&D.

The NITRD Program,² composed of 25 member agencies with a total of over 80 participating agencies, focuses its work on strategic R&D imperatives that lead to cutting-edge technologies and strengthens U.S. competitiveness. The NITRD Program, now in its 31st year, was launched by the High-Performance Computing (HPC) Act of 1991 and reauthorized by Congress in 2017.³ This Supplement fulfills the mandate to submit to Congress annually a Supplement to the President's Budget in which member agencies describe their R&D budget in HPC, IT, and networking. NITRD's interagency communication and collaboration in IT R&D leverage agency strengths, help avoid duplication, and foster development of interoperable systems, thus improving the cost-effectiveness of Federal research investments.

Included in this Supplement is the budget and program information required to be submitted to Congress annually by the National Artificial Intelligence Initiative Act (NAIIA). This report provides a status of the National AI Research Institutes as called for in the National Artificial Intelligence Initiative Act of 2020.

The NITRD Program objectives are to coordinate Federal agency networking in IT R&D; foster the transition of research innovations into practical use; provide the IT R&D foundations for assuring continued U.S. leadership in science and technology; support investments that develop tools and technologies with the potential to open new areas of discovery; and increase government accountability and efficiency with advanced IT.

Through NITRD, Federal agencies exchange information; collaborate on research plans and activities such as testbeds, workshops, strategic planning, and cooperative solicitations; and focus their R&D resources on common goals of making new discoveries and developing new technology solutions. The NITRD Program provides a framework and mechanisms for

¹ <https://www.whitehouse.gov/wp-content/uploads/2022/07/M-22-15.pdf>

² <https://www.nitrd.gov>

³ NITRD was reauthorized by Congress in the American Innovation and Competitiveness Act of 2017 (P.L. 114-329) <https://www.congress.gov/bill/114th-congress/senate-bill/3084/text>.

coordination that support R&D in advanced networking and information technology and leverages IT advances arising from Federal R&D investments to address our nation's most critical priorities.

The National Artificial Intelligence Initiative Office (NAIIO)⁴ provides a coordinated program across the entire Federal government to harness the benefits and mitigate the risks of AI. The mission of the NAIIO is to ensure continued U.S. leadership in AI R&D, lead the world in the development and use of trustworthy AI in the public and private sectors, and prepare the present and future U.S. workforce for the integration of AI systems across all sectors of the economy and society. The NAIIA Federal agencies now invest approximately \$110 million in 25 AI Research Institutes.

This Supplement is organized by Program Component Areas (PCAs) and related interagency working groups. The PCAs are the major subject areas under which Federal agencies report their budget, and the Interagency Working Groups (IWGs) are composed of the agencies with investments in the associated PCAs. This Supplement provides NITRD members' budget reporting for the most recently completed budget cycle, the current budget cycle, and the budget requests for the next fiscal year.

1.1 NITRD Program Component Areas

NITRD's annual budget is organized by Program Component Areas (PCAs) and an agency to facilitate year-to-year budgetary and programmatic trend analysis. The PCAs are categories of technical R&D focus areas supported by NITRD member agency investments. PCAs are the major subject areas under which Federal agencies report their funding requests for their NITRD-related activities. Following a major revision in FY 2023, the NITRD PCAs were reviewed to ensure that the NITRD Program actively addresses evolving IT R&D and policy needs. The NITRD web page provides information on each fiscal year's PCA definitions.⁵ Following are the FY 2024 NITRD PCAs:

- Advanced Communication Networks and Systems (ACNS)
 - Advanced Wireless R&D (AWRD) (sub-PCA)
- Artificial Intelligence (AI) R&D
- Computing-Enabled Human Interaction, Communication, and Augmentation (CHuman)
- Computing-Enabled Networked Physical Systems (CNPS)
- Cyber Security and Privacy (CSP)
- Education and Workforce (EdW)
- Electronics for Networking and Information Technology (ENIT)
- Enabling R&D for High-Capability Computing Systems (EHCS)
- High-Capability Computing Infrastructure and Applications (HCIA)
- Intelligent Robotics and Autonomous Systems (IRAS)
- Large-Scale Data Management and Analysis (LSDMA)
- Software Productivity, Sustainability, and Quality (SPSQ)

⁴ <https://www.ai.gov>

⁵ <https://www.nitrd.gov/program-component-areas/>

1.2 NITRD Interagency Working Groups

NITRD's Interagency Working Groups (IWGs) coordinate the R&D planning and activities that support members' PCA investments. There is a close, though not strictly one-to-one, match between the PCAs and IWGs (see Table 4 and Section 3.0). The NITRD IWGs, with rotating agency co-chairs and support from NCO Technical Coordinators, strive to maximize Federal interagency efficiency in conducting high-impact basic research, transferring discoveries to the marketplace, advancing the national IT R&D infrastructure, and strengthening community R&D alliances. IWGs share information and coordinate agency R&D activities via monthly coordination meetings, annual planning meetings, and the development of technical strategic plans. The NCO and IWG members review the IWG definitions and strategic R&D priorities annually to ensure they align with the Administration's annual and ongoing priorities. Following are the FY 2024 NITRD IWGs and subgroups:

<ul style="list-style-type: none"> • Artificial Intelligence R&D (AI) <ul style="list-style-type: none"> ○ Video and Image Analytics (VIA) team • Big Data • Computing-Enabled Networked Physical Systems (CNPS) • Cyber Security and Information Assurance (CSIA) • Digital Health R&D (DHRD) • High End Computing (HEC) • Information Integrity R&D (IIRD) • Intelligent Robotics and Autonomous Systems (IRAS) 	<ul style="list-style-type: none"> • Large Scale Networking (LSN) <ul style="list-style-type: none"> ○ Broadband Research and Development (BRD) team ○ Joint Engineering Team (JET) ○ Middleware and Grid Interagency Coordination (MAGIC) team • Privacy R&D (Privacy) • Software Productivity, Sustainability, and Quality (SPSQ) • Wireless Spectrum R&D (WSRD)
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Figure 1 shows the relationships of the IWGs to the PCAs in which their investments are reported.

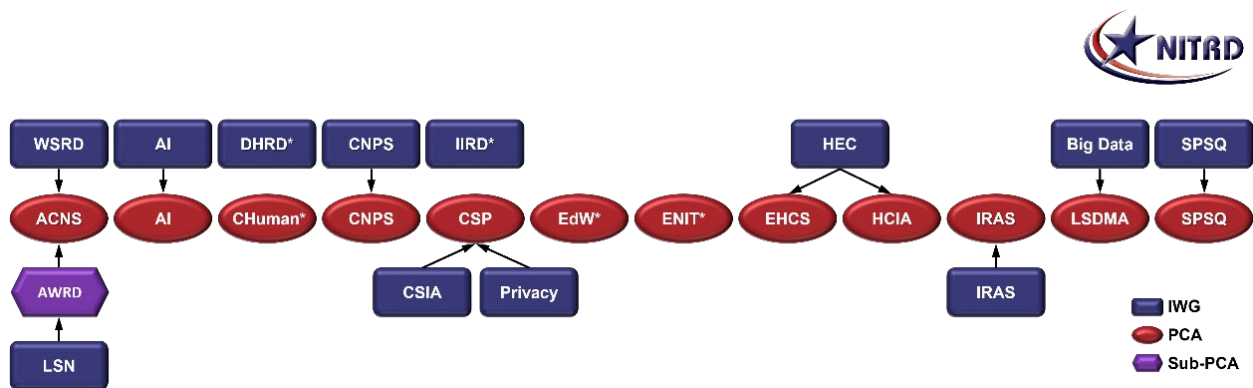


Figure 1. Relationships Between the NITRD IWGs and PCAs for FY 2024

*Notes: The DHRD IWG and IIRD IWG are not affiliated with a single PCA. The CHuman, EdW, and ENIT PCAs do not have coordinating IWGs; agencies that invest in R&D in these areas currently do so within other IWGs.

1.2.1 Community Engagement

NITRD's IWGs are committed to public-private partnerships through various forms of community engagement and public outreach. This commitment to coordination, collaboration, and transparency has contributed to growing participation and increasing R&D funding in the Program's pursuit of NITRD innovation and public access to it. This commitment is carried out through the various activities of the IWGs:

- Host public and private sector and civil society speakers at meetings on relevant R&D topics to explore opportunities for public awareness and engagement.
- Announce public meetings, workshops, conferences, listening sessions, and speaker series in the Federal Register, to encourage broad participation.
- Solicit broad-based community inputs during the development of R&D strategic plans and implementation plans⁶ through Federal Register Requests for Information (RFIs) and listening sessions. The RFIs are authorized, guided, cleared, and published by OSTP and NSTC and resulting responses are made available online to the NITRD community and the public broadly.⁷

NITRD provides strategies and opportunities for public access to information. A weekly NITRD News Brief offers insight into the activities NITRD's member agencies are conducting to achieve the Nation's priorities through the lens of the public-facing news sources. The NITRD website includes dissemination of selected NIT topics in the press; Federal Register Announcements; NITRD and NAIIO Supplements to the President's Budget; current and historical documents to include, strategic plans, roadmaps, and various other scientific and technical documents relating to NITRD activities.⁸

The National AI Initiative Office's website⁹ is the connection point to ongoing activities to advance U.S. leadership in AI.

⁶See NITRD's Publication Library, <https://www.nitrd.gov/publications/>, publication types: *Federal Plan, Implementation Plan/Roadmap, Scientific and Technical Report, and Strategic Plan.*

⁷ <https://www.nitrd.gov/apps/federal-register-documents/>

⁸ <https://www.nitrd.gov/>

⁹ <https://www.ai.gov/>

1.2.2 NSTC S&T Collaborations

NITRD's interdisciplinary R&D agenda creates natural synergies between its IWG efforts and other efforts of the NSTC enterprise, including those of the Subcommittees listed in Figure 2.

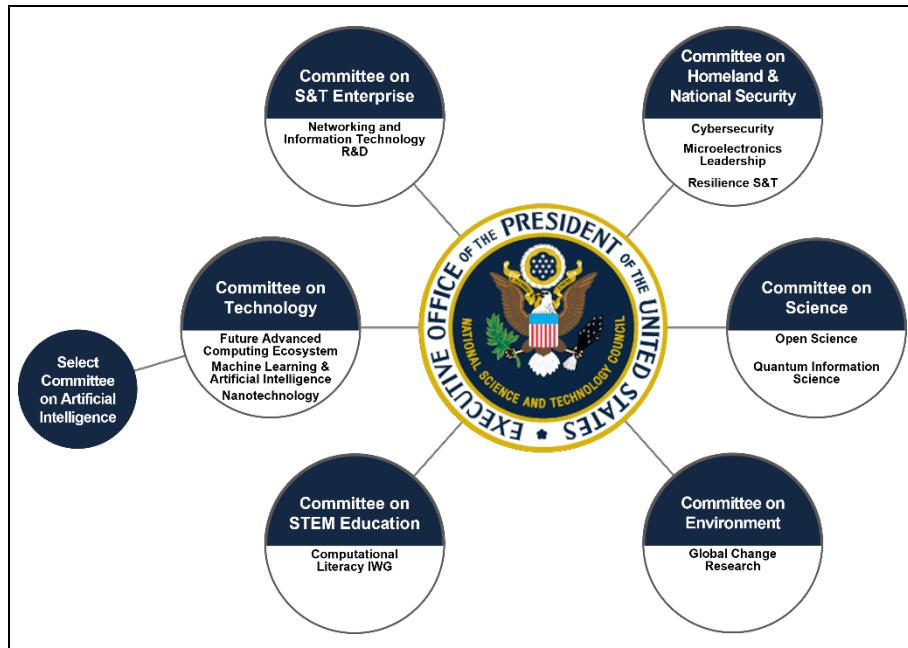


Figure 2. Collaborations with Other NSTC S&T Committees and Subcommittees

Collaborations with these NSTC Committees and Subcommittees advances the National Research Ecosystem, bringing to fruition integrated data, compute, software, and education resources and an open data forum for the information technology and science communities. Several examples of these collaborations are:

- The NITRD Subcommittee, Artificial Intelligence R&D IWG, in collaboration with the Subcommittee on Machine Learning and Artificial Intelligence, and the Select Committee on Artificial Intelligence published a *National Artificial Intelligence Research and Development Strategic Plan 2023 Update*.¹⁰ In addition, they collaborate on:
 - AI Research Program Repository¹¹ to provide the AI research community with a comprehensive directory of all active Federal AI R&D programs to raise awareness and accessibility of funding opportunities and potential collaborations.
 - AI R&D Testbed Inventory¹² for researchers to locate Federally supported testbeds and testing resources needed for their research.
- The NITRD Subcommittee, Cyber Security and Information Assurance IWG, in collaboration with the Subcommittee on Special Cyber Operations Research and Engineering is developing an update to the *2019 Federal Cybersecurity R&D Strategic Plan* as required by the Cybersecurity Enhancement Act of 2014.

¹⁰ <https://www.nitrd.gov/pubs/National-Artificial-Intelligence-Research-and-Development-Strategic-Plan-2023-Update.pdf>

¹¹ <https://www.nitrd.gov/apps/ai-research-program-repository/>

¹² <https://www.nitrd.gov/apps/ai-rd-testbed-inventory/>

- The NITRD Program is furthering Science, Technology, Engineering, and Math (STEM) activities with its member and participating agencies and worked closely with the Committee on STEM, to advance, strengthen, and build computational literacy in STEM education.¹³ NITRD has developed a comprehensive STEM Portal,¹⁴ which provides information on Federal internships, fellowships, scholarships, and other training programs. This portal is proactively managed and promoted through the NITRD website, news briefs, and social media.

1.3 Structure of This Supplement

This document contains five main sections and one appendix.

Section 2.0 provides budget data for Federal R&D investments made in FY 2022 and enacted in FY 2023 (as well as supplementals), and requests for the President's FY 2024 Budget in the 12 NITRD PCAs. It also provides breakouts of agency budgets that support AI R&D, the National AI Research Institutes, and advanced wireless networking R&D.

Section 3.0 describes the major R&D priorities and key activities and programs reported by NITRD agencies under the PCAs and coordinated by the IWGs.

Section 4.0 describes the major R&D priorities and key activities and programs reported by the IWGs without an affiliated PCA.

Section 5.0 describes each National AI Research Institute.

Appendix A contains the abbreviations and acronyms used in this document.

¹³ *Building Computational Literacy Through STEM Education: A Guide For Federal Agencies and Stakeholders*, to be published

¹⁴ <https://www.nitrd.gov/stem4all/>

2.0 Agency NITRD- and NAIIO-Related R&D Investments, FY 2022–FY 2024

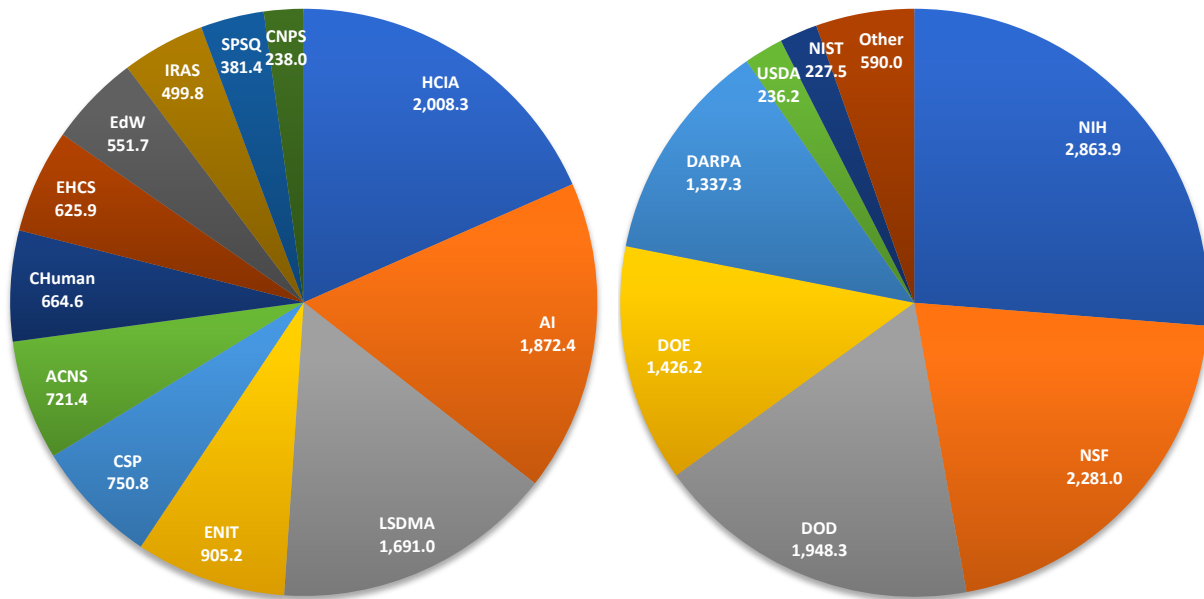
The Biden-Harris Administration commitment to making historic investments in innovation and research is evident in the NITRD budget crosscut, with the President's overall FY 2024 budget request for Federal agencies' NITRD-related R&D (see [Table 1](#)) increasing 13.5 percent to \$10.9 billion—compared to the \$9.6 billion originally requested for FY 2023.¹⁵

The overall increase in NITRD investment requests is bolstered by the increase of 19.2 percent in FY 2024 AI R&D requested investment across the NITRD agencies to \$3.1 billion (see [Table 2](#)), up from the \$2.6 billion originally requested for FY 2023.¹⁵ Similarly, the National AI Research Institutes FY 2024 budget request is an increase of 19.8%, for a total request of \$110.1 million (see [Table 3](#)), across six agencies: NSF, DHS, DOD, Department of Education Institute of Education Sciences (ED-IES), USDA/NIFA, and NIST.

Expanding R&D in advanced wireless communications (AWN) focuses on building wireless connectivity that can bridge the digital divide and provide equal access to Internet resources. Agencies' budget requests for FY 2024 AWN R&D ([Table 4](#)) total \$295.4 million, an increase of approximately 16.2 percent compared to the \$254.3 million originally requested for AWN R&D for FY 2023.¹⁵

2.1 Budget Charts and Tables

Figure 3 shows the FY 2024 Budget Request by PCA (a) and agency (b). See the NITRD Dashboard for investments and trends for FY 2002–FY 2024.¹⁶



a. FY 2024 Budget Request, in millions, of the total NITRD request, by PCA

b. FY 2024 Budget Request, in millions, of the total NITRD request, by agency

See Appendix A for spell-outs of PCA and agency acronyms.

*Other: AHRQ, DHS, DOE/ NNSA, DOI, DOT, ED-IES, EPA, FDA, NARA, NASA, NIJ, NIOSH, NOAA, NTIA, Treas./FinCEN, and VA

Figure 3. FY 2024 Budget Request as Percentages of the Total NITRD Request

¹⁵ <https://www.nitrd.gov/pubs/FY2023-NITRD-NAIIO-Supplement.pdf>

¹⁶ <https://www.nitrd.gov/apps/itdashboard/dashboard/>

2.1.1 Agency Budgets by NITRD PCA

Note: FY 2022 refers to the final FY 2022 budget authority available (actuals), FY 2023 refers to activities funded under FY 2023 enacted appropriations, and FY 2024 refers to activities funded within the FY 2024 President’s budget request. Fiscal years with "-S" after them denote supplemental funding.

Table 1. Agency Budgets by NITRD PCA, FYs 2022–2024

Agency	FY	12 NITRD Program Component Areas												Totals
		ACNS	AI	CHuman	CNPS	CSP	EdW	ENIT	EHCS	HCIA	IRAS	LSDMA	SPSQ	
AHRQ	2022	0.0	0.0	16.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.3
	2023	0.0	0.0	16.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.3
	2024	0.0	0.0	18.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.3
DARPA	2022	54.0	429.8	0.0	0.0	242.4	0.0	419.9	5.1	0.0	0.0	25.9	0.0	1,177.1
	2023	74.2	400.5	0.0	0.0	183.8	0.0	708.7	5.1	0.0	0.0	31.8	0.0	1,404.1
	2024	59.6	322.1	0.0	0.0	207.5	0.0	710.0	5.1	0.0	0.0	33.0	0.0	1,337.3
DHS	2022	7.0	41.4	0.0	8.0	54.4	2.2	4.0	0.0	0.0	6.5	7.8	0.0	131.3
	2023	6.7	38.6	0.0	14.5	49.7	1.6	4.0	0.0	0.0	3.8	1.6	0.0	120.5
	2024	4.6	34.3	0.0	8.7	38.0	1.0	0.0	0.0	0.0	2.1	1.5	0.0	90.3
DOD	2022	136.7	227.5	162.4	18.3	149.5	144.3	11.0	49.5	189.2	258.2	197.4	34.7	1,578.7
	2022-S	19.5	1.3	3.8	0.0	0.2	0.0	0.0	34.3	0.0	10.9	0.0	0.0	69.9
	2023	222.1	241.3	163.4	17.9	159.3	153.0	54.5	33.6	256.5	309.2	226.0	33.3	1,870.1
	2023-S	26.3	0.0	0.0	0.0	10.0	0.0	0.0	30.0	0.0	7.6	0.0	0.0	73.9
	2024	250.3	274.0	168.1	22.4	172.4	148.2	55.8	32.2	261.6	326.3	201.7	35.3	1,948.3
DOE	2022	95.9	133.2	0.3	1.9	47.3	29.6	0.0	158.8	678.9	5.4	0.0	0.0	1,151.1
	2022-S	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	163.8	0.0	0.0	0.0	163.8
	2023	106.0	136.0	5.3	2.8	52.5	54.0	0.0	152.0	780.9	14.9	0.0	0.0	1,304.3
	2023-S	0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0
	2024	101.2	141.8	0.3	2.2	55.0	83.3	0.0	210.6	830.8	1.0	0.0	0.0	1,426.2
DOE/ NNSA	2022	1.4	31.2	0.0	0.0	0.7	2.0	0.0	24.0	0.0	1.8	0.0	0.0	61.1
	2023	0.4	33.9	0.0	0.0	0.4	2.0	0.0	16.0	0.0	3.1	0.0	0.0	55.7
	2024	0.0	28.0	0.0	0.0	0.0	2.0	0.0	28.0	0.0	2.8	0.0	0.0	60.8
DOI	2022	0.0	8.8	0.0	0.0	0.0	0.0	0.0	0.0	2.1	0.0	1.0	0.0	11.9
	2023	0.0	13.7	0.0	0.0	0.0	0.0	0.0	0.0	5.8	0.0	0.0	0.0	19.5
	2024	0.0	34.2	0.0	0.0	0.0	0.0	0.0	0.0	26.4	0.8	1.0	0.0	62.4
DOT	2022	0.0	6.3	0.0	0.0	5.3	0.0	0.0	0.0	0.0	7.8	0.3	1.9	21.5
	2023	0.0	8.8	0.0	0.0	7.3	0.0	0.0	0.0	0.0	7.0	0.6	0.9	24.5
	2024	0.0	10.3	1.0	0.0	7.9	0.0	0.0	0.0	0.0	5.0	0.8	1.5	26.5
ED-IES	2022	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2023	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2023-S	0.0	0.0	0.0	0.0	0.0	12.9	0.0	0.0	0.0	0.0	0.0	0.0	12.9
	2024	0.0	0.0	0.0	0.0	0.0	2.1	0.0	0.0	0.0	0.0	0.0	0.0	2.1
EPA	2022	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.3	3.5	0.0	0.0	0.0	6.8
	2023	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.3	3.5	0.0	0.0	0.0	6.8
	2024	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.3	3.5	0.0	0.0	0.0	6.8
FDA	2022	0.0	32.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	32.4
	2022-S	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
	2023	0.0	39.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	39.8
	2023-S	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2

2.0 Agency NITRD- and NAIIO-Related R&D Investments, FY 2022–FY 2024

Agency	FY	12 NITRD Program Component Areas												Totals
		ACNS	AI	Chuman	CNPS	CSP	EdW	ENIT	EHCS	HCIA	IRAS	LSDMA	SPSQ	
NARA	2024	0.0	35.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	35.8
	2022	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2023	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5
	2024	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
NASA	2022	0.0	2.9	0.0	5.3	0.0	0.0	0.0	3.0	76.6	26.3	5.1	1.8	120.9
	2023	0.0	4.0	0.0	5.3	0.0	0.0	0.0	3.1	69.9	27.7	4.6	1.8	116.3
	2024	0.0	4.0	0.0	5.3	0.0	0.0	0.0	3.2	83.6	24.0	1.2	1.8	123.0
NIH	2022	33.6	268.8	332.3	18.8	18.3	72.9	19.4	142.2	414.5	28.5	1,061.1	231.4	2,641.8
	2022-S	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.5	0.0	7.1
	2023	34.5	288.2	348.0	19.6	19.1	77.0	20.3	156.5	477.6	29.6	1,114.3	245.0	2,829.7
	2023-S	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.8	0.0	3.1
	2024	34.5	284.5	359.1	19.6	19.9	78.5	20.3	148.2	471.7	29.6	1,153.0	245.0	2,863.9
NIJ	2022	0.0	5.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.8
	2023	0.0	8.0	0.0	0.0	0.0	1.5	0.0	0.0	0.0	0.0	0.3	0.0	9.8
	2024	0.0	8.0	0.0	0.0	0.0	1.5	0.0	0.0	0.0	0.0	0.3	0.0	9.8
NIOSH	2022	0.0	9.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.6	0.0	0.0	14.1
	2023	0.0	8.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.8	0.0	0.0	12.2
	2024	0.0	8.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.8	0.0	0.0	12.2
NIST	2022	12.4	26.0	14.8	9.4	84.2	13.7	0.0	9.1	9.7	8.7	14.0	2.9	204.9
	2023	9.4	31.0	9.2	8.3	95.8	9.6	0.0	8.9	10.0	9.5	14.1	2.8	208.6
	2024	9.4	31.0	8.7	8.3	115.8	9.0	0.0	8.9	10.0	9.5	14.1	2.8	227.5
NOAA	2022	4.3	0.0	0.2	0.0	0.0	0.0	0.0	0.0	70.5	0.0	0.0	3.7	78.7
	2022-S	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.0	0.0	0.0	3.4	28.4
	2023	4.3	0.0	0.2	0.0	0.0	0.0	0.0	0.0	93.4	0.0	0.0	5.7	103.6
	2024	4.3	0.0	0.2	0.0	0.0	0.0	0.0	0.0	91.9	0.0	0.0	5.2	101.6
NSF	2022	212.6	506.5	111.1	82.9	120.0	95.6	72.8	180.0	209.6	48.1	222.2	67.3	1,928.7
	2022-S	4.1	5.4	4.6	2.8	2.9	6.2	0.4	1.1	0.3	0.9	2.8	0.4	32.0
	2023	204.9	418.4	90.8	123.5	117.8	115.5	89.6	165.8	209.4	53.8	221.3	74.4	1,885.2
	2023-S	7.3	24.5	1.1	15.6	3.6	6.7	10.8	0.2	0.6	4.6	13.8	2.9	91.5
	2024	237.5	531.3	108.9	166.6	134.3	143.1	119.1	186.3	228.9	69.9	265.4	89.8	2,281.0
NTIA	2022	11.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.3
	2022-S	150.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	150.0
	2023	12.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.6
	2023-S	1,350.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1,350.0
	2024	20.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.0
Treas./ FinCEN	2022	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4
	2023	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
	2024	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
USDA	2022	0.0	93.2	0.0	5.0	0.0	66.0	0.0	0.0	0.0	19.0	16.0	0.0	199.2
	2022-S	0.0	0.0	0.0	0.0	0.0	140.0	0.0	0.0	0.0	0.0	0.0	0.0	140.0
	2023	0.0	95.2	0.0	5.0	0.0	72.0	0.0	0.0	0.0	21.0	17.0	0.0	210.2
	2024	0.0	104.2	0.0	5.0	0.0	83.0	0.0	0.0	0.0	25.0	19.0	0.0	236.2

Agency	FY	12 NITRD Program Component Areas												Totals
		ACNS	AI	CHuman	CNPS	CSP	EdW	ENIT	EHCS	HCIA	IRAS	LSDMA	SPSQ	
VA	2022	0.0	15.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.0
	2023	0.0	21.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	21.0
	2024	0.0	20.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.0
Totals	2022	569.2	1,838.6	637.4	149.6	722.0	426.3	527.1	575.0	1,654.6	414.8	1,550.8	343.7	9,409.0
	2022-S	173.6	7.4	8.4	2.8	3.1	146.2	0.4	35.4	189.1	11.8	9.3	3.8	591.4
	2023	675.0	1,787.6	633.3	196.9	685.6	486.1	877.1	544.2	1,907.0	483.3	1,631.6	363.9	10,271.7
	2023-S	1,383.6	27.9	1.1	15.6	13.6	19.6	10.8	30.2	0.6	12.2	16.6	2.9	1,534.6
	2024	721.4	1,872.4	664.6	238.0	750.8	551.7	905.2	625.9	2,008.3	499.8	1,691.0	381.4	10,910.5

Table 1 Notes:

- Fiscal years with "-S" after them denote supplemental funding.
- Amounts are in U.S. dollars in millions.
- Budget supplemental figures for FY 2022 and FY 2023 have not been used to calculate changes between the FY 2022 and FY 2023 budget numbers.
- Agency sub-departments and offices that reported budgets are as noted here (see the Abbreviations list at the end of this document): DHS: CG, CWMD, S&T, and TSA; DOD: DTRA, MDA, Military Services' research organizations (now including Space Force), and OSD; DOE: ARPA-E, CESER, EERE, FE, NE, OE, and SC; DOE/NNSA: Defense Nuclear Nonproliferation and Defense Programs; DOI: BSEE, USBR, and USGS; DOT: FAA, FHWA, FMCSA, FRA, and FTA; NASA Mission Directorates: Aeronautics Research, Science, and Space Technology; NOAA: ORF and PAC; NSF: Education and Human Resources, and Research and Related Activities; USDA: ARS and NIFA.
- The AI budget reported under the AI PCA is not the complete AI budget; refer also to [Tables 2 and 3](#) and the Budget Analysis at the end of this section.
- Totals might not sum exactly as a result of rounding.
- DARPA is a DoD research organization, but it reports its budgets separately from the DoD Services research organizations and the Office of the Secretary of Defense (OSD).
- The DOE/NNSA budget is listed separately from that of other DOE offices.

2.1.2 Agency Budgets by NITRD PCA for AI R&D

Note: FY 2022 refers to the final FY 2022 budget authority available (actuals), FY 2023 refers to activities funded under FY 2023 enacted appropriations, and FY 2024 refers to activities funded within the FY 2024 President’s budget request. Fiscal years with "-S" after them denote supplemental funding.

Table 2. Agency Budgets by NITRD PCA for AI R&D, FYs 2022–2024

Agency	FY	Agencies' AI Budgets												Totals
		AI	ACNS	CHuman	CNPS	CSP	EdW	ENIT	EHCS	HCIA	IRAS	LSDMA	SPSQ	
AHRQ	2022	0.0	0.0	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.5
	2023	0.0	0.0	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.5
	2024	0.0	0.0	2.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.8
DARPA	2022	429.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	429.8
	2023	400.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	400.5
	2024	322.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	322.1
DHS/ Coast Guard	2022	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5
	2023	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4
	2024	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
DHS/ CWMD	2022	2.5	0.2	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	3.4
	2023	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3

	FY	Agencies' AI Budgets												Totals
		AI	ACNS	CHuman	CNPS	CSP	EdW	ENIT	EHCS	HCIA	IRAS	LSDMA	SPSQ	
	2024	3.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.4
DHS/ S&T	2022	31.4	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	31.9
	2023	31.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	31.2
	2024	25.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.0
DHS/ TSA	2022	7.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.0
	2023	7.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.0
	2024	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.0
DOD/ Army	2022	75.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	75.3
	2023	95.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	95.8
	2024	103.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	103.5
DOD/ DAF	2022	53.4	8.6	4.2	0.0	14.2	1.4	0.9	6.0	0.0	2.2	9.7	0.0	100.6
	2022-S	0.0	3.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.9
	2023	60.5	7.4	8.5	0.0	15.4	1.7	0.5	6.2	0.0	8.8	29.4	0.0	138.6
	2023-S	0.0	5.3	0.0	0.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.8
	2024	61.1	7.4	19.5	0.0	17.1	5.3	0.3	6.0	0.0	8.6	18.5	0.0	143.8
DOD/ DTRA	2022	9.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.0
	2023	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.0
	2024	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0
DOD/ MDA	2022	4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0
	2023	7.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.2
	2024	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5
DOD/ Navy	2022	61.5	0.0	7.7	0.0	0.0	10.5	0.0	0.0	0.0	4.8	66.9	0.0	151.4
	2022-S	0.0	0.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0	1.7	0.0	0.0	3.3
	2023	50.5	0.0	7.5	0.0	0.0	12.6	0.0	0.0	0.0	4.6	51.5	0.0	126.6
	2022-S	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	1.0
	2024	78.3	0.0	7.5	0.0	0.0	10.1	0.0	0.0	0.0	4.6	59.8	0.0	160.2
DOD/ OSD	2022	18.3	0.0	0.0	0.9	3.4	0.4	0.0	0.0	0.0	1.2	1.0	0.0	25.2
	2023	14.5	0.0	0.0	0.0	2.6	1.1	0.0	0.1	0.0	6.0	0.0	0.0	24.4
	2024	18.0	0.0	0.0	0.0	3.2	0.1	0.0	0.0	0.0	0.4	0.0	0.0	21.7
DOD/ Space Force	2022	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.0
	2022-S	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3
	2023	6.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.8
	2024	6.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.6
DOE/ EERE	2022	24.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24.7
	2023	26.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	26.2
	2024	27.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	27.9

	FY	Agencies' AI Budgets												Totals
		AI	ACNS	CHuman	CNPS	CSP	EdW	ENIT	EHCS	HCIA	IRAS	LSDMA	SPSQ	
DOE/FE	2022	11.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.7
	2023	10.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.3
	2023-S	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0
	2024	13.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.7
DOE/NE	2022	2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.4
	2023	3.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.8
	2024	4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0
DOE/ NNSA	2022	31.2	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	31.5
	2023	33.9	0.0	0.0	0.0	0.2	0.0	0.0	3.2	0.0	0.0	0.0	0.0	37.3
	2024	28.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	28.0
DOE/OE	2022	6.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.2
	2023	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2024	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DOE/SC	2022	88.2	0.0	0.0	0.0	0.0	0.0	0.0	16.5	43.7	0.0	0.0	0.0	148.4
	2023	95.7	0.0	0.0	0.0	0.0	0.0	0.0	19.8	50.3	0.0	0.0	0.0	165.8
	2024	96.3	0.0	0.0	0.0	0.0	0.0	0.0	19.9	50.9	0.0	0.0	0.0	167.0
DOI/ BSEE	2022	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
	2023	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
	2024	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
DOI/ USBR	2022	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2023	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2024	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.5
DOI/ USGS	2022	8.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6	0.0	0.0	0.0	10.2
	2023	13.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.4	0.0	0.0	0.0	17.8
	2024	34.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.8	0.0	0.0	0.0	53.8
DOT/ FAA	2022	1.4	0.0	0.0	0.0	2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.9	4.7
	2023	1.9	0.0	0.0	0.0	2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.5	4.8
	2024	1.0	0.0	0.0	0.0	3.2	0.0	0.0	0.0	0.0	0.0	0.0	1.0	5.2
DOT/ FHWA	2022	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8
	2023	3.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.5
	2024	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0
DOT/ FMCSA	2022	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
	2023	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8
	2024	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5
DOT/ FRA	2022	2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.2
	2023	2.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.6
	2024	1.8	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.8

	FY	Agencies' AI Budgets												Totals
		AI	ACNS	CHuman	CNPS	CSP	EdW	ENIT	EHCS	HCIA	IRAS	LSDMA	SPSQ	
DOT/ FTA	2022	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
	2023	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2024	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0
ED-IES	2022	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2023	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2023-S	0.0	0.0	0.0	0.0	0.0	12.9	0.0	0.0	0.0	0.0	0.0	0.0	12.9
	2024	0.0	0.0	0.0	0.0	0.0	2.1	0.0	0.0	0.0	0.0	0.0	0.0	2.1
FDA	2022	32.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	32.4
	2022-S	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
	2023	39.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	39.8
	2023-S	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
	2024	35.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	35.8
NARA	2022	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2023	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5
	2024	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
NASA/ AERO.	2022	2.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.9
	2023	4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0
	2024	4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0
NASA/ SCIENCE	2022	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	2.3	0.0	0.0	0.0	2.8
	2023	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	2.1	0.0	0.0	0.0	2.6
	2024	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	8.4	0.0	0.0	0.0	8.8
NIH	2022	268.8	6.4	99.0	4.9	4.0	23.9	0.0	42.4	72.5	11.1	273.8	53.7	860.4
	2022-S	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6
	2023	288.2	6.5	103.7	5.1	4.1	25.3	0.0	46.6	83.6	11.5	287.5	56.8	919.0
	2023-S	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
	2024	284.5	6.5	107.0	5.1	4.3	25.7	0.0	44.2	82.5	11.5	297.5	56.8	925.7
NIJ	2022	5.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.8
	2023	8.0	0.0	0.0	0.0	0.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0	9.5
	2024	8.0	0.0	0.0	0.0	0.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0	9.5
NIOSH	2022	9.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	0.0	0.0	10.9
	2023	8.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0	9.5
	2024	8.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0	9.5
NIST	2022	26.0	0.5	0.0	0.0	0.0	0.0	0.0	2.4	0.0	2.6	0.0	0.0	31.5
	2023	31.0	0.2	0.0	0.0	0.0	0.0	0.0	2.4	0.0	2.6	0.0	0.0	36.2
	2024	31.0	0.2	0.0	0.0	0.0	0.0	0.0	2.4	0.0	2.9	0.0	0.0	36.4

	FY	Agencies' AI Budgets												Totals
		AI	ACNS	CHuman	CNPS	CSP	EdW	ENIT	EHCS	HCIA	IRAS	LSDMA	SPSQ	
NOAA/ ORF	2022	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.5	1.5
	2023	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.5	1.5
	2024	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.5	1.5
NOAA/ PAC	2022	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	1.0	2.0
	2022-S	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	1.0	3.0
	2023	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	0.0	0.0	3.5	4.9
	2024	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6	0.0	0.0	2.0	3.5
NSF	2022	506.5	21.3	26.7	24.0	24.0	6.8	2.2	12.6	12.6	28.4	48.9	6.1	720.0
	2022-S	5.4	0.3	1.6	0.8	0.6	0.4	0.0	0.1	0.0	0.9	0.7	0.0	11.0
	2023	418.4	22.5	28.2	22.2	28.3	7.4	4.5	13.3	16.8	27.4	44.3	4.5	637.6
	2023-S	24.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24.5
	2024	531.3	21.4	31.6	21.7	24.2	8.0	2.4	14.9	18.3	30.8	47.8	5.4	757.6
NTIA	2022	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1
	2023	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1
	2024	0.0	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6
TREAS/ FCEN	2022	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4
	2023	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
	2024	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
USDA/ ARS	2022	27.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	27.2
	2023	27.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	27.2
	2024	27.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	27.2
USDA/ NIFA	2022	66.0	0.0	0.0	4.6	0.0	6.6	0.0	0.0	0.0	18.4	13.1	0.0	108.7
	2023	68.0	0.0	0.0	4.6	0.0	7.2	0.0	0.0	0.0	20.4	13.9	0.0	114.1
	2024	77.0	0.0	0.0	4.6	0.0	8.3	0.0	0.0	0.0	24.3	15.6	0.0	129.7
VA	2022	15.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.0
	2023	21.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	21.0
	2024	20.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.0
Totals	2022	1,838.6	38.1	140.0	35.1	48.2	50.2	3.1	80.3	134.7	70.2	413.4	62.2	2,914.1
	2022-S	7.4	4.2	3.1	0.8	0.6	0.4	0.0	0.1	2.0	2.6	0.7	1.0	23.1
	2023	1,787.6	38.0	150.4	31.9	53.1	56.7	5.0	92.2	159.6	82.4	426.6	65.8	2,949.2
	2022-S	27.9	5.3	0.0	0.0	1.5	12.9	0.0	0.0	0.0	1.0	0.0	0.0	48.6
	2024	1,872.4	37.5	169.2	31.3	51.9	61.1	2.7	87.8	182.5	84.1	439.6	65.7	3,085.8

FY	Agencies' AI Budgets													Totals
	AI	ACNS	CHuman	CNPS	CSP	EdW	ENIT	EHCS	HCIA	IRAS	LSDMA	SPSQ		

Table 2 Notes:

- Fiscal years with "-S" after them denote supplemental funding.
- Amounts are in U.S. dollars in millions.
- Budget supplemental figures for FY 2022 and FY 2023 have *not* been used to calculate changes between the FY 2022 and FY 2023 budget numbers.
- For full names of agency subcomponents (departments and offices), please see Appendix A.
- Totals might not sum exactly as a result of rounding.
- (1) Examples of AI R&D investments reported under the AI PCA are R&D on general methods for machine vision; (primarily) machine learning; cybersecurity challenges unique to AI (e.g., ability to exploit flaws in an AI system’s goals); algorithms for computational linguistics; and neuromorphic computing architectures or chips optimized for neural nets.
- (2) Examples of AI investments reported in other PCAs are R&D on robots (reported in IRAS); the data analysis and management ecosystem (reported in LSDMA); broad issues of human-machine interaction (reported in CHuman) and cybersecurity research (reported in CSP); and general neuromorphic computing (reported in EHCS).

2.1.3 Agency Budgets for NSF-Led National AI Research Institutes

Note: FY 2022 refers to the final FY 2022 budget authority available (actuals), FY 2023 refers to activities funded under FY 2023 enacted appropriations, and FY 2024 refers to activities funded within the FY 2024 President’s budget request.

Table 3. Agency Budgets for NSF-Led National AI Research Institutes, FYs 2022–2024

FY	Agencies						Totals
	NSF	DHS	DOD	ED-IES	NIFA	NIST	
2022	53.9	2.0	0		20.0	2.0	77.9
2023	52.0	2.0	2.0	12.9	20.0	3.0	91.9
2024	74.0	2.0	2.0	2.1	20.0	10.0	110.1

Notes for Table 3:

- Amounts are in U.S. dollars in millions.
- Totals might not sum exactly as a result of rounding.
- Industry and other private partners contribute to some National AI Research Institutes (see [Section 5.0](#)).

2.1.4 NITRD Agency Budgets for Advanced Wireless Networking R&D

Note: FY 2022 refers to the final FY 2022 budget authority available (actuals), FY 2023 refers to activities funded under FY 2023 enacted appropriations, and FY 2024 refers to activities funded within the FY 2024 President’s budget request. Fiscal years with "-S" after them denote supplemental funding.

Table 4. NITRD Agency Budgets for AWN R&D, FYs 2022–2024

FY	Agencies							Totals
	DARPA	DOD/Navy	DOE/NE	NIH	NIST	NSF	NTIA	
2022	27.0	17.6		25.6	6.2	161.6	11.3	249.3
2022-S						2.6	150.0	152.6
2023	36.0	24.4	0.1	26.2	6.3	153.7	12.6	259.3
2023-S						7.3	1,350.0	1,357.3
2024	34.6	30.0	0.2	26.2	6.3	178.1	20.0	295.4

FY	Agencies							Totals
	DARPA	DOD/Navy	DOE/NE	NIH	NIST	NSF	NTIA	
Notes for Table 4: <ul style="list-style-type: none"> • Figures break out those portions of NITRD member agencies' R&D investments in the ACNS PCA that are primarily dedicated to advanced wireless networks. • Fiscal years with "-S" after them denote supplemental funding. • Amounts are in U.S. dollars in millions. • DOE/NE and NIH are new this fiscal year. • AWN R&D investments are typically coordinated through NITRD's WSRD IWG. • Totals might not sum exactly as a result of rounding. 								

2.2 Changes in Overall Agency Budgets, FY 2023 to FY 2024

Table 5 shows changes of investment greater than \$10 million, by agency and PCA, between the FY 2023 enacted budgets and the FY 2024 budget requests.

Table 5. Changes of >\$10 Million in Investment

Agency	Description
DARPA	The decrease of \$66.8 million is due to decreases of \$78.4 million in AI which reflects a ramping down and completion of several DARPA AI program from FY 2023 to FY 2024 and \$14.6 million in ACNS due to the completion of the Network Universal Persistence program in FY 2024 and the ramp down in the Mission Integrated Network Control program. These are partially offset by an increase of \$23.7 million in CSP for the initiation of the Carcosa and Constellation programs and smaller increases in other PCAs.
DHS	The decrease of \$30.2 million is due to a decrease of \$11.5 million in CSP at DHS S&T due to reductions in Transnational Organized Crime and Counter Networks and smaller decreases in other programs and PCAs.
DOD	The increase of \$78.2 million is due to increases of \$32.7 million in AI partially due to an increase in the Navy's Cooperative Engagement Capability Increment II, \$28.2 million in ACNS partially due increases to the Army's Hypersonics, \$17.1 million in IRAS, \$13.1 million in CSP, and smaller increases in CHuman, CNPS, ENIT, HCIA, and SPSQ; these increases are partially offset by a decrease of \$24.3 million in LSDMA partially due to a number of Air Force's programs that map to LSDMA ending in FY 2023 and smaller decreases in other PCAs.
DOE	The increase of \$121.9 million is a result of increases of \$55.0 million in EHCS at DOE/SC for new Microelectronics centers, increase in foundational Computer Science research in support of Energy Earthshots, and some shifting of funding across categories to improve consistency; \$46.3 million in HCIA at DOE/SC for significant increase in operations costs for the Aurora exascale system, increases in applied mathematics, and minor increases and decreases in other areas; \$12.0 million in EdW at DOE/EERE; \$11.3 million in EdW at DOE/SC for Computational Science Graduate Fellowship and RENEW efforts. These are partially offset by a decrease of \$13.2 million in IRAS at DOE/ARPA-E, with smaller increases and decreases in other programs and PCAs.
DOI	The increase of \$42.9 million is due to increases of \$20.6 million in HCIA and \$20.6 million in AI at USGS and smaller increases and decreases in other programs and PCAs.
NIH	The increase of \$30.5 million is a result of an increase of \$35.0 million in LSDMA for COVID-19 pandemic related data initiatives, \$11.1 million in CHuman for new modes of healthcare delivery for the Helping End Addiction Long-term initiative, and new pragmatic clinical trials to detect cognitive impairment, and smaller increases and decreases in other PCAs.
NIST	The increase of \$18.9 million is a result of increase in CSP due to the Cybersecurity initiative requested in President's budget. This increase is offset by smaller decreases CHuman and EdW.

Agency	Description
NSF	The increase of \$395.8 million across all PCAs is related to the overall increase for Research and Related Activities at the FY 2024 Request level to enhance fundamental R&D and strengthen U.S. leadership in emerging technologies. Increased investments in the National AI Research Institutes and the Technology, Innovation and Partnerships Directorate contributed to larger than average increases in the AI, CNPS, ENIT, and IRAS PCAs.
USDA	The increase of \$26.0 million is due to increases of \$11.0 million in EdW at NIFA to fund NEXTGEN and smaller increases in AI, IRAS, and LSDMA.

3.0 Key Activities of the NITRD PCAs and IWGs

Member and participating agencies coordinate and collaborate on R&D programs through the NITRD IWGs. The following subsections contain a description of the NITRD PCAs and the R&D activities of agencies participating in the associated IWGs.

Note: Education and workforce development investments reported within relevant PCAs might be detailed within the EdW PCA (Section 3.6) to provide a more holistic picture of agency efforts in this administration priority.

3.1 Advanced Communication Networks and Systems (ACNS) PCA

ACNS R&D advances and validates communication networks and systems, including wireless, optical, or quantum communication technologies and services; this includes R&D in networking architectures, programmability, security, measurement, performance, robustness, resilience, and interoperability, along with techniques for advancing spectrum efficiency.

3.1.1 Large Scale Networking (LSN) IWG

Participating Agencies: *AFRL, Army, Army DEVCOM C5ISR Center, ARS, CISA, DAF, DARPA, DHS S&T, DISA, DOD, DOD CIO, DOE/SC, DOJ, DREN, EPA, FCC, FDA, GSA, NASA, Navy, NIH, NIST, NOAA, NRC, NRL, NSA, NSF, NTIA, OMB, ONR, OSD, OUSD(R&E), State, USAGM, USTR*

The LSN IWG coordinates Federal R&D in networking technologies and services, including network architectures, wired and wireless network infrastructures, grid and cloud middleware research, and communication protocols, to enable the robust transfer of data among ground, sea, air, and space systems.

3.1.1.1 Strategic Priorities and Associated Key Programs

Following are the LSN IWG's strategic priorities and relevant programs.

1. Develop concepts, techniques, architectures, and protocols for future networks.

- Develop new technologies, programmable measurement techniques, methodologies, resilient and intelligent next-generation networks and systems, and testbeds and demonstration capabilities (e.g., 5G architectures and in-network computing and storage). *AFRL, DARPA, DOE/SC, DREN, NIST, NOAA, NSA, NSF, OUSD(R&E)*
- Advance quantum communications and networking. *AFRL, DOE/SC, NIST, NSF, OUSD(R&E)*
- Provide connectivity and communications in contested and congested environments. *AFRL, Army DEVCOM C5ISR Center, DARPA, OUSD(R&E)*
- Incorporate AI/ML aspects for better adaptation to the communications layer in convergent networks. *AFRL, Navy, NSF, NIST*
- Deploy next-generation high-performance wide area networks. *DOE/SC, DREN*
- Support FABRIC Network Testbed. *DOE/SC, NSF, OUSD(R&E)*
- Advance space-based communications. *DARPA, OUSD(R&E)*
- Assess terahertz viability for use in Air Force airborne environments. *AFRL*

- Advance software-defined networking automation and programmability capabilities in the ESnet6 Network. *DOE/SC*
- Develop a scalable web-based system for data quality checking and secure data exchange that will standardize and coordinate data sharing across international research networks. *NIH*

2. Develop cloud infrastructure enhancements.

- Conduct network technology and systems R&D, develop new hardware for future cloud systems, advance reproducibility research for cloud systems, and examine the edge-to-cloud continuum. *NIST, NSA, NSF*
- Develop roadmaps for the adoption of cloud computing technologies and commercial cloud use. *DOE/SC, NIH, NIST*
- Adopt and accelerate 5G Network Prototypes. *DOD, OUSD(R&E), NIST*
- Connect tactical information across multiple domains on demand, at scale, and securely. *AFRL, DARPA, OUSD(R&E)*
- CloudBank: Enhance access to cloud computing resources for the computing research community. *NSF*
- Cloud-based Computer Vision Smart Steering Sleeve sensor system. *NIH*
- Commercial Cloud Computing Strategy: Experiments in the use of commercial cloud computing services to support resiliency and surge needs of science communities. *DOE/SC*
- Cyclone: Research towards protecting sensitive data in use for large dynamic distributed systems. *NSA*
- eMERGE Network: Provide new expertise in large-scale genotyping, cloud computing, and genomic data analysis and management. *NIH*
- Enhance DREN cloud programs: Boundary Cloud Access Point, Direct Connect Cloud Access, and Secret DREN connections to Secret commercial cloud providers. *DREN*
- Future Cloud: Multi-site experimental computing and networking infrastructure to innovate for future cloud computing software and networks. *NSF*
- Operationalize N-Wave cloud broker services and support directly connecting to the commercial cloud. *NOAA*

3. Develop enhanced, next-generation network architecture capabilities for data analytics.

- Explore the capabilities of AI/ML to enhance data analytics on programmable and 5G and NextG networks. *AFRL, Army DEVCOM C5ISR Center, NIST, NSA, NSF, OUSD(R&E)*
- Enhance advanced, distributed computing architecture capabilities and next-generation supercomputing support for science needs. *DOE/SC, DREN, NIH, NOAA, NSF*
- Develop an end-to-end, virtualized, programmable, self-optimizing network architecture. *DARPA, NSF, ONR, OUSD(R&E)*
- Provide command and control and situational awareness capabilities. *AFRL, DARPA, OUSD(R&E)*
- Advance the design of edge computing and edge networking infrastructure and develop scalable platforms for data analytics for emerging Internet of Things (IoT) devices. *NSF, OUSD(R&E)*

- Clinical and Translational Science Centers. *NIH*
- Enhance DREN Active Measurement Program. *DREN*
- Open Network Automation Platform. *NSA*
- Platform for Explainable Distributed Infrastructure. *DOE/SC*
- Scalable AI Approaches for Cyberthreat Remediation, Elimination, and Deterrence. *NSA*
- Technology Development and Innovation Program. *NOAA*
- Internet measurement research program for methodologies, tools, and infrastructure. *NSF*

4. Develop, evaluate, and standardize technologies to achieve security and resilience in emerging wireless networks and multidomain internets to protect core network infrastructure.

- Enhance cybersecurity awareness, protections, and capabilities through developing new services and tools (e.g., cybersecurity for IoT, AI tools). *AFRL, Army DEVCOM C5ISR Center, DHS S&T, Navy, DOE/SC, DREN, NIST, NOAA, NSF, ONR, OUSD(R&E)*
- Support cyber technology innovations for trustworthy and secure networks (e.g., 5G and trustworthy AI), data and supply chain security, and infrastructure monitoring. *Army DEVCOM C5ISR Center, DHS S&T, DOE/SC, NIH, NIST, NSA, NSF, ONR, OUSD(R&E)*
- Support research advances as well as the development and testing of resilient and intelligent NextG systems. *DOD, NIST, NSF, OUSD(R&E), industry partners*

5. Develop technology, standards, testbeds, and tools to improve wireless networks.

- Develop nontraditional waveforms and technologies for resilient communications. *AFRL, Army DEVCOM C5ISR Center, DARPA, Navy, NSF, ONR, OUSD(R&E)*
- Deploy and operate nationwide testbeds supporting performance monitoring and protocol development. *AFRL, DOE/SC, NSF*
- Develop techniques to improve trust, performance, and robustness of wired and wireless networked sensors and control systems. *NIST, NSA, NSF, OUSD(R&E)*
- Develop and operate testbeds supporting the testing and evaluation of radio access network disaggregation technologies, develop and operate testbeds supporting the testing and evaluation of open-source implementations of next-generation network components, and develop standards for the evolution of spectrum sharing between 5G and NextG systems and other incompatible radio systems. *NIST, NSF*
- 5G Coexistence Testbed (sub-6GHz and mm wave): Provide carrier-grade implementation with a focus on metrology for emerging 5G spectrum sharing, coexistence, and interference testing. *NIST*
- Develop cloud-based systems to collect time-based behavioral and biometric data from patient digital health devices in real-life settings to improve caregiving and treatment. *NIH*
- Enhance DREN 4 Service Delivery Point-Lite Capability over Wireless Networks. *DREN*
- Expand wireless service and deploy rapid, mobile site deployments. *NOAA*
- Explore the use of new technologies, including eHealth and machine (deep) learning to diagnose and manage HIV-associated cancers. *NIH*
- Future G. *OUSD(R&E)*
- IoT Monitoring and Anomaly Detection. *NSA*

- Large-scale Self-driving 5G Network for Science. *DOE/SC*
- Research and develop methodologies and tools to assess the interoperability, performance, security, and resilience of emerging open RAN solutions. *NIST, OUSD(R&E)*
- Explore new methodologies and tools for mobile and wireless Internet performance through an Internet measurement research program. *NSF*

3.1.1.2 Key Coordination Activities

- Advanced Communications Technologies Working Group. *Army, DAF, DISA, DOD CIO, FDA, EPA, GSA, NASA, Navy, NIST, NRC, NTIA, State, USAGM, USTR*
- LSN Joint Engineering Team (JET): Coordinate R&D activities in networking, advanced technologies, end-user requirements, user interfaces, research and storage networks, end-to-end big data testbeds and metrics, trusted Internet connections, and tools. *DOE/SC, DREN, FCC, NASA, NIH, NIST, NOAA, NRL, NSF, NTIA, industry and academic partners*
- Advance integration of advanced wireless with large scientific instruments and advance network protocol development. *DOE/SC, DREN, NIST, NOAA, NSA, NSF*
- Federal IPv6 Task Force. *CISA, DOJ, DREN, GSA, NIST*
- LSN Middleware and Grid Interagency Coordination (MAGIC) team: Coordinate activities in identity management, distributed computing, middleware, cloud, and grid computing services and information exchanges; standards and implementation; resource architecture, access, and management best practices; and security and privacy. *DOE/SC, FCC, NIST, NRL, NSF, OUSD(R&E), ARS, academic and industry partners*
- Pursue distributed infrastructure architectures that integrate instruments, sensors, computers, storage, and networks into a coherent whole. *DOE/SC, DREN, NIST, NOAA, NSA, NSF, OUSD(R&E)*
- Community of Interests for Cyber and C4I (Command, Control, Communications, Computers, and Intelligence). *AFRL, Army, Army DEVCOM C5ISR Center, Navy, OUSD(R&E)*
- Electromagnetic Spectrum Working Group. *AFRL, Army, Army DEVCOM C5ISR Center, Navy, OUSD(R&E)*
- DREN Technical Interchange Meeting. *DOE, DREN, NASA, NOAA*
- N-Wave Stakeholders Science and Engagement Summit. *DOD, NIST, NOAA, NTIA*
- High-fidelity whole system modeling and simulation methods and algorithms. *DOD, DOE/SC, NSF*
- Next-generation network innovations; Scientific Computing: Open Science Grid, CC* Science DMZ, Field Programmable Gate Array Accelerator Research Infrastructure Cloud. *DOD, DOE/SC, NSF, OUSD(R&E)*
- Platforms for Advanced Wireless Research: Support advanced wireless research platforms conceived by the U.S. academic and industrial wireless research community. *FCC, NSF*
- Secure Systems Research: Cybersecurity Innovation for Cyberinfrastructure, DeterLab. *DHS, NSF*

Advanced Wireless R&D (AWRD) Sub-PCA

AWRD includes Federal spectrum-related R&D investments that promote the efficient use of wireless spectrum through advanced technologies and systems. Investments under this sub-PCA are coordinated by and reported under the WSRD IWG.

3.1.2 Wireless Spectrum R&D (WSRD) IWG

Participating Agencies: Air Force, Army DEVCOM C5ISR Center, DARPA, DEA, DHS, DOE/NNSA, DOE/SC, DOJ/OCIO, DOJ (NIJ), FAA, DOT, FCC, FDA, NASA, Navy, NIST, NOAA, NSF, NTIA, OSD

The WSRD IWG coordinates Federal spectrum-related R&D activities to facilitate effective R&D investments that promote efficient use of wireless spectrum through advanced technologies and systems.

FY24 Administration Priorities: WSRD Examples

Advancing National Security and Technological Competitiveness: 5G Challenge

Accelerate the adoption of open interfaces, interoperable subsystems, and modular, multi-vendor solutions. This public prize challenge approach will support the growth of a large, vibrant community working on 5G multi-vendor interoperability. This approach is a powerful catalyst for creating diverse solutions, attracting non-traditional performers, and sparking new innovations. DOD OUSD (R&E), NTIA, ITS. (<https://5gchallenge.ntia.gov/>)

Cultivating an Equitable STEM Education, Engagement, and Workforce Ecosystem: Spectrum Innovation Initiative

Promote dynamic and agile spectrum utilization, while ensuring innovation and security for all users. Reaching this goal will require basic research, infrastructure development, new collaborations, public outreach, education, and workforce development. NSF, NTIA, FCC. (https://www.nsf.gov/mps/oma/spectrum_innovation_initiative.jsp)

Promoting Open Science and Community-Engaged R&D: Next Generation Wireless Next G Channel Model Alliance

A NIST-sponsored international research consortium working to advance breakthrough measurement, calibration, and channel modeling approaches and technologies used for mmWave and submillimeter-wave frequencies. NIST, FCC. (<https://www.nist.gov/ctl/nextg-channel-model-alliance>)

3.1.2.1 Strategic Priorities and Associated Key Programs

Following are the WSRD IWG's strategic priorities and relevant programs.

1. Improve the performance of communications and other spectrum-dependent systems through better operation in shared and congested spectrum bands, dynamic use of higher and multiple frequency bands, and adaptation to the spectrum environment.

- Hill Air Force Base Testbed: Analyze interactions between C-band 5G base stations and DAF radar systems and advise on interference mitigation approaches. *DOD, NTIA*

- Next Generation Wireless: Develop the world’s best channel-sounding systems (millimeter-wave & sub-THz bands), novel propagation models, integrated communications and sensing systems, and novel antenna measurement methods to enable next-generation communications systems. *NIST, OUSD(R&E)*
- Space-Based Adaptive Communications Node: Aims to revolutionize the way space-based communications work by developing low-cost, high-speed reconfigurable optical datalinks to connect various low-earth orbit (LEO) constellations. *DARPA, OUSD(R&E)*
- Space-based optical communications: Advance and demonstrate space-based optical communications technologies while cultivating the U.S. industrial base to implement the capabilities. *NASA, OUSD(R&E)*
- Space-based radio frequency (RF) communications: Portfolio of projects to expand the use of the growing commercial market and to develop RF capabilities in higher frequency bands. *NASA, OUSD(R&E)*
- Fundamental Electromagnetic Technologies and Standards: Develop measurement science to characterize the performance of wireless systems and underlying technology through measurements made in non-conductive environments. *NIST*
- CISE/CNS Core Research Programs: Design and analysis of high-performance wireless networks. *NSF*
- ENG/ECCS Core Research Programs: Research in circuit and system hardware, signal processing techniques, and network architectures for communications and sensing. *NSF*

2. Enhance robustness, resilience, and reliability of spectrum-dependent systems and networks in the face of spectrum access challenges, threats by malicious actors, limited available power, and other constraints.

- Resilient and Intelligent Next Generation Systems (RINGS): Supports the research on emerging next generation (NextG) wireless and mobile communication, networking, sensing, and computing systems, along with global-scale services. *DOD, NIST, NSF, OUSD(R&E)*
- Core Network Technologies Trustworthy Networks Research: Develop and apply measurement techniques to improve the resilience and robustness of core network infrastructures including inter-domain routing, software defined virtual networks, Network of Things, and 5G Core. *NIST, NSF, OUSD(R&E)*
- C-V2X (cellular vehicle-to-everything): Research, model, simulate and evaluate new communications technologies for the transportation sector. *DOT, NTIA*
- Remote Sensing and “Living with RFI”: Apply and develop signal processing techniques for both passive (e.g., radiometers) and active (e.g., radar) science sensors to detect and remove or mitigate effects from radio frequency interference (RFI). *NASA, NSF, OUSD(R&E)*
- Smart Connected Systems Cybersecurity for Smart Grid systems: Develop a cybersecurity risk management strategy for the smart grid to enable secure interoperability of solutions across different domains and components. *NIST, NSF*
- Resilient Wideband SATCOM: Increase the resiliency of Wideband Satellite Communications (SATCOM) in a congested and contested environment to support air, land, sea, space, and cyber-integrated operations. *Army DEVCOM C5ISR Center, OUSD(R&E)*

- Data Protection in Virtual Environments: Fully homomorphic encryption computation within a factor of ten unencrypted computations, enabling data security for all states of data across DOD and commercial applications. *DARPA*
- Device-level Anomaly fRamEwork (DARE): Identify anomalous behavior through cross-layer analysis of the physical, data, and network layers, combining RF emissions with data and network measurands. *NIST*
- NextG Supply Chain Security: Develop techniques for non-invasive multiple-layer measurements of advanced microelectronics to detect cyber-attacks, hardware trojans, and counterfeit components. *NIST*
- Regulatory Science Tools for the Evaluation of 5G Connectivity in Medical Devices: Develop testbeds and evaluation methods for evaluating the safety and effectiveness of 5G-enabled medical devices. *FDA*
- Space Communications and Navigation Network Integrity: Operates networks and secures commercial services to provide space communication services to spaceflight missions. *NASA*

3. Increase the overall utilization of the electromagnetic spectrum through better systems and mechanisms for spectrum and interference management, sensing, sharing, monitoring, control, prediction, adaptation, and protection.

- Office of Polar Programs. *NSF, NTIA*
- Radio Frequency Interference Monitoring System. *NOAA, NTIA*
- Future G. *DOD, OUSD(R&E)*
- Electromagnetic compatibility: Interference protection criteria and system or scenario-level simulation. *NTIA, OUSD(R&E)*
- Joint University Microelectronics Program (JUMP). *DARPA*
- NASA Electronic Radio Database System: Enable efficient and effective reporting and support to spectrum management processes. *NASA*
- National Radio Dynamic Zones: Use-inspired research to accelerate the use of dynamic spectrum sharing. *NSF*
- Remote Sensing and “Living with RFI”: Apply and develop signal processing techniques for both passive (e.g., radiometers) and active (e.g., radar) science sensors to detect and remove or mitigate effects from RF interference (RFI). *NASA*
- Spectrum Analysis Center: Develop and maintain necessary software to analyze spectrum access including assessments of potential RFI useful for both domestic and international spectrum processes. *NASA*
- Spectrum management R&D. *NTIA*
- Spectrum Sharing and Sensing: Develop robust test processes, measurement technologies, and validated measurement data necessary to advance the evaluation and deployment of spectrum sharing and management technologies, coexistence metrics, atmospheric gas sensing, precision timing across networks, and calibrations. *NIST*
- Spectrum and Wireless Innovation enabled by Future Technologies: Fundamental research on resilient and responsive spectrum sharing, particularly with passive systems, and the use of AI for effective spectrum utilization and coordination. *NSF*

4. Develop trustworthy measurement-based data-driven algorithms, analytics, and models to inform system design, spectrum policy, and management.

- DOD National Advanced Spectrum and Communications Test Network (NASCTN) sharing ecosystem assessment. *DOD, NASA, NIST, NTIA*
- DOD mid-band propagation modeling. *DOD, NTIA*
- Open-source propagation models and tooling with cross-language support, utilizing a defined software development cycle and software best-practices. *NTIA*
- Next Generation Wireless: Develop novel channel measurement methods and models in support of next-generation wireless systems leveraging NIST NextG Channel Model Alliance private-public partnerships. *NIST*
- NSF Spectrum Innovation Centers. *NSF*
- Propagation modeling website: ITS or locally hosted propagation analysis toolset provided to end-users through a website frontend and a backend processing system. *NTIA*
- Radio Spectrum Measurement Sciences/Spectrum Monitoring: Spectrum occupancy studies and broadband surveys and sensor and algorithm development. *NTIA*

5. Accelerate assessment of spectrum innovations and their translation into practice through better capabilities and facilities for modeling, simulation, and testing.

- DOD 5G Challenge. *DOD, NTIA*
- Advanced Communication Test Site. *NTIA, OUSD(R&E)*
- Antenna Communication and Metrology Laboratory: Enable metrology research on advanced antenna systems operating in complex electromagnetic environments. *NIST, OUSD(R&E)*
- 5G Coexistence Testbed. *NIST*
- Calibration Services for Wireless Communications, providing traceability to national standards from materials to devices to systems used in wireless calibrations. *NIST*
- Community Infrastructure for Research in Computer and Information Science and Engineering. *NSF*
- Data Technology & Software Engineering. *NTIA*
- Industrial Wireless Systems Testbed. *NIST*
- National Broadband Interoperability Testbed. *NIST*
- Next Generation Communications Research. *NTIA, OUSD(R&E)*
- Platforms for Advanced Wireless Research. *NSF*
- Public Safety Communication Innovation Laboratory. *NIST*
- Rapid Test and Deployment: Small satellite, bundled services, and commercial procurement and practices. *NASA*
- Translational Impacts: Accelerate the translation of research results to practice. *NSF*

3.1.2.2 Key Coordination Activities

- Interagency Council on Standards Policy (ICSP) Advanced Communications Technologies Working Group: Facilitate coordination of Federal agency advanced communications technologies (ACT) standards activities, responds to requests for information, and develops recommendations relating to ACT standards policy matters to the ICSP. *CDC, DHS, DOD, DOT, EPA, GSA, HHS, NIST, NRC, NTIA, State, USDA*
- Provide robust test processes and validated measurement data necessary to develop, evaluate and deploy spectrum sharing technologies that can improve access to the spectrum by both Federal agencies and non-federal spectrum users. *DOD, NASA, NIST, NOAA, NSF, NTIA*
- 5G Supplier Diversity Working Group: Identify concrete and actionable steps that the U.S. Government, in partnership with industry, can take concerning vendor diversity and 5G. *DOD, NIST, NTIA, NSF, State*
- Future Generation Wireless Roadmap Working Group: Forecast the evolution of communications technology over the next 20+ years to determine R&D gaps and target resources to deliver the greatest impact to industry. *DARPA, DOD, FCC, NIST, academic and industry partners*
- International Symposium on Advanced Radio Technologies: Bring together government, industry, and academic leaders (both domestic and international) to forecast the development and application of advanced radio technologies. *DARPA, DHS, NSF, NTIA, OUSD(R&E), academic and industry partners*
- Resilient and Intelligent NextG Systems: Accelerate research to improve resiliency and other performance metrics of emerging NextG wireless and mobile communication, networking, sensing, and computing systems, along with global-scale services. *DOD, NIST, NSF, industry partners*
- DOD Electromagnetic Spectrum Working Group. *Army DEVCOM C5ISR Center, DAF, DOD, Navy, OUSD(R&E)*
- Interdepartment Radio Advisory Committee: Incorporate specialized subcommittees, such as those assisting NTIA in assigning frequencies and in developing policies, procedures, and technical criteria for managing the Federal use of spectrum. *NASA, NSF, NTIA*
- NIST NextG Channel Model Alliance: Facilitate global efforts to measure and define the radio channel models where next-generation 5G and beyond wireless will operate. *NIST, NSF, NTIA, academic and industry partners*
- Spectrum Innovation Initiative: Address the pressing challenges arising from the growing demand for the usage of the electromagnetic spectrum, including passive and active applications; and promote dynamic and agile spectrum utilization, while ensuring innovation and security for all users. *FCC, NASA, NSF*
- National Academies' Committee on Radio Frequencies: Consider the needs for RF requirements and interference protection for scientific and engineering research, coordinate the views, and act as a channel for representing the interests of U.S. scientists. *NASA, NSF*
- Public Safety Innovation Accelerator Program: Accelerate R&D that directly impacts first responder communications and operations, specifically in areas of Mission Critical Voice, Location-Based Services, and User Interface or User Experience. *NIST, NSF*

3.2 Artificial Intelligence (AI) PCA

AI R&D advances the technical capabilities of computational systems to conduct, simulate, or extend the performance of tasks that have traditionally required human intelligence; this includes innovations in perception (to include spoken language and gestures), computer vision, natural language technologies, representation, learning, reasoning, recommendation, and action; novel and use-inspired application of these techniques to various domains; and examination of trustworthiness and the associated measurements, methods, and tools needed for designing, developing, and evaluating such systems.

3.2.1 Artificial Intelligence R&D IWG

Participating Agencies: *ACL, AFOSR, AFRL, AHRQ, Army, CDC, CMS, DAF, DARPA, DHS, DOD, DOE/NNSA, DOE/SC, DOT, DTRA, FDA, FHWA, HRSA, IHS, Marine Corp, MDA, NAIIO, NASA, Navy, NIFA, NIH, NIJ, NIOSH, NIST, NRO, NSA, NSF, NTIA, ODNI, NMIO, ONC, OUSD(R&E), OSTP, SAMHSA, TRMC, USPTO, USSF, VA*

The AI R&D IWG coordinates Federal AI R&D and supports activities tasked by the Subcommittee on Machine Learning and Artificial Intelligence and the NAIIO. This vital work promotes U.S. leadership and global competitiveness in AI R&D and its applications.

FY24 Administration Priorities: AI R&D Examples

Advancing National Security and Technological Competitiveness: Trustworthy and Responsible AI

Advance AI evaluations to strengthen research communities, establish research methodologies, support the development of standards, and facilitate technology transfer. NIST, NSF. (<https://www.nist.gov/trustworthy-and-responsible-ai>)

Tackling Climate Change: EarthCube

Create a well-connected environment to share data and knowledge for all the geosciences in an open, transparent, and inclusive manner and to accelerate our ability to understand and predict the Earth system. NSF. (<https://www.nsf.gov/geo/earthcube/>)

Preparing For and Preventing Pandemics: Next Generation Advancing Computer Modeling and Epidemiology for Bio-preparedness and Response

Develop automated workflows that are interoperable with DOE leadership computing systems to help researchers with the deluge of data generated during biological events. DOE. (<https://www.energy.gov/science/articles/department-energy-announces-5-million-research-computer-modeling-and-epidemiology>)

3.2.1.1 Strategic Priorities and Associated Key Programs

Following are the AI R&D IWG's strategic priorities, as defined by the *National Artificial Intelligence Research and Development Strategic Plan 2023 Update*.¹⁷ and relevant programs.

¹⁷ <https://www.nitrd.gov/pubs/National-Artificial-Intelligence-Research-and-Development-Strategic-Plan-2023-Update.pdf>

1. Make long-term investments in AI research.

- National AI Research Institutes: Advance foundational and use-inspired research; build AI talent pool; create nexus points for academia, government, and industry. *DHS, DOD, ED, NIST, NSF, USDA, industry partners*
- AI Risk Management Framework: Identify and quantify trustworthy and responsible AI in technical terms and develops tools and guidance. *DOE, DOD, NIST, NSF, academic and industry partners*
- Assured DevSecOps of Autonomous Systems: Develop test and evaluation solutions for AI. *AFOSR, AFRL, Army, DAF, Marine Corps, Navy*
- Autonomy and AI Test: Investments of transformational autonomy and AI Test and Evaluation technologies. *Navy, TRMC*
- Advanced Air Mobility: Support aviation markets to safely develop air transportation systems using AI that transports people and cargo between places using revolutionary new aircraft. *NASA*
- Advancing Measurement Science using ML AI in Use-inspired Research: Gain deeper insight into measurement challenges as well as to better understand AI's capabilities and limitations. *AFOSR, NIST*
- Agriculture and Food Research Initiative: Address research challenges in agriculture using AI. *NIFA*
- AI and Scientific Machine Learning: Develop AI as an enabling technology for scientific insights and discovery. *AFOSR, DOE/SC*
- AI for Science, Energy, and Security: AI research primarily focused on the use of AI for science, energy, and national security applications. *DOE*
- AI, ML, and Data for Scientific User Facilities: AI research portfolios in physics and basic energy sciences for autonomous control and experimentation, data analysis, and offline design and optimization of user facilities. *AFOSR, DOE/SC*
- AI to address Alzheimer's Disease: AI approaches that lead to the identification of gene mutations and variants that cause or contribute to the risk of or protection against the development of Alzheimer's disease and Alzheimer's disease-related dementias. *NIH*
- Computing and Communication Foundations: Advances computing and communication theory, algorithms for computer and computational sciences and architecture and the design of computers and software. *AFOSR, NSF*
- Earth System Digital Twins: Towards understanding the evolution and interactions of Earth's most complicated systems. *NASA*
- Environment-driven Conceptual Learning: Create AI agents capable of continually learning from language and vision to enable a human-machine collaborative analysis of image, video, and multimedia documents. *AFOSR, DARPA*
- Exploratory Advanced Research Program: Explore and develop AI systems to plan, build, renew, and operate safe, congestion-free, and environmentally sound transportation systems. *DOT*
- Ground Test Predictive Analysis Concepts: Develop AI algorithms to identify anomalies within Ground Test data runs. *MDA*

- Information and Intelligent Systems: Study interrelated roles of people, computers, and information to mimic intelligence in computational systems. *AFOSR, NSF*
- Intramural Research Programs: Research for clinical medical image processing, high-throughput genomic technologies, and analysis. *NIH*
- Machine Common Sense: Develop machine common sense capabilities that learn from experience with objects, agents, and places or that learn by reading. *AFOSR, DARPA*
- Nuclear AI/ML Environment: Establish a repository and collaborative space for AI, ML, and data science efforts related to nuclear deterrence. *DTRA*
- Long Range Robotic Space Exploration: AI and communication architectures for multiple mission types. *AFOSR, NASA*
- Radiation-Tolerant Neuromorphic Processor: Develop neuromorphic processors and high-performance vector central processing units that support AI in space. *AFOSR, NASA*
- Specialty Crop Research Initiative: Develop resources that accelerate the application of scientific discovery and technology to solve the needs of the various specialty crop industries. *NIFA*
- Unique Computational Paradigms for Ultra-efficient AI Hardware: Research and benchmark unconventional approaches to brain-inspired hardware and architectures. *NIST*

2. Develop effective methods for human-AI collaboration.

- Operational Trust in Mission Autonomy: Establishes an understanding of trust in AI-enabled systems, and methods to measure and assess it in human-agent collaboration. *AFRL, Navy, OUSD(R&E) CTO, TRMC*
- Autonomous Discovery in Science and Engineering: Open-source and community development of methods, algorithms, and software for enabling autonomous scientific discovery. *AFOSR, DOE/SC, international partners*
- Adaptive Human Computer Interfaces: ML to understand normal usage patterns and identify anomalies due to crew member difficulties, such as health impairment. *NASA*
- Aegis human-machine teaming. *MDA*
- Aeronautics Human Contributions to Safety Task: Build data-informed understanding of humans' safety-producing behaviors to ensure that future AI and Human-AI collaborative systems retain a robust capability for resilient performance. *NASA*
- AI Tools for Materials Discovery, Design, and Characterization: Characterize materials, predict their properties, inform researchers through visualizations, and iteratively suggest experiments. *NASA*
- AI Usability: Develop software and standards to lower barriers to AI-researcher interactions while enhancing AI interpretability and preserving trustworthiness. *NIST*
- Autism Spectrum Disorders: Develop AI research designed to elucidate the etiology, epidemiology, diagnosis, and optimal means of service delivery concerning Autism Spectrum Disorders. *NIH*
- Automated Rapid Certification of Software: Automate the evaluation of software assurance evidence to enable certifiers to determine rapidly that system risk is acceptable. *DARPA*
- Biomechanical modeling of exoskeleton use. *NIOSH*

- Distributed Sensing and Model Driven Prediction: Develop a system for firefighters in which lots of diverse sensors combine to provide cohesive situational awareness. *DHS*
- Human-Centered Computing: Support research in human-computer interaction to design new computing systems to amplify physical, cognitive, and social capabilities. *NSF*
- Human Language Technologies: Improve teaching of collaborative argumentation. *NSF*
- Smart-path planning for collaborative robots. *NIOSH*
- Methods for accessing protective materials; Auto-coding of occupational databases; Natural Language Processing (NLP) of injury and fatality reports. *NIOSH*
- Predict safety and stability of mining engineering. *NIOSH*

3. Ethical, legal, and societal implications of AI.

- Explainable and Interpretable AI; Bias in AI; AI transparency; Safe AI; Privacy-preserving ML. *AFOSR, NIST, NSF*
- Federated Learning and Privacy-Preserving AI Research: AI research for predictive models from collectively shared, privacy-sensitive datasets. *DOE/SC, NIH*
- Accountable AI: Develop an ecosystem for auditing AI and other autonomous systems. *NTIA*
- Advance Search and Discovery: Using AI, NLP, and data science along with subject matter experts to make the decades of nuclear test information in the nuclear archives at Defense Threat Reduction Information Analysis Center more discoverable for research on nuclear deterrence and nuclear effects. *DTRA*
- Ethical issues in Translational Science Research: Anticipate and Address Ethical Challenges in Applications of ML and AI. *NIH*
- Explainable AI: Explanations for why anomalies and their precursors in aviation data are identified as such. *NASA*
- Model Drift and Bias Detection: Understand how bias enters the model through data and algorithms. *DHS*
- Strengthening data-driven pretrial release in New Jersey: Examines pretrial risk assessments, that have been criticized for inherent bias and exacerbating racial disparities. *NIJ*
- Incarcerated Population Communications: Examine feasibility and appropriateness of AI, ML, NLP, and other technologies to monitor, analyze, and transcribe nonprivileged incarcerated population communications into actionable intelligence. *NIJ*

4. Ensure the safety and security of AI systems.

- Assured DevSecOps of Autonomous Systems. Develop an assurance and trust framework for an autonomous Apache. *Army, TRMC*
- Assured Neuro Symbolic Learning and Reasoning: Enable high levels of trust in autonomous systems through new, hybrid AI algorithms that integrate symbolic reasoning with data-driven learning. *DARPA*
- Cybersecurity: ML to automatically tag NASA data for security sensitivity. *NASA*
- Explainable AI; AI Risk: Landscape analysis. *DHS*
- Guaranteeing AI Robustness against Deception: Develop defenses against adversarial deception attacks on ML models. *DARPA*

- Learning Introspective Control: Develop ML-based introspection technologies that enable physical systems to respond to events not predicted at design time. *DARPA*
- Risk Management for AI: Maintain a comprehensive reference guide for risk identification and recommended mitigations to support responsible and trustworthy AI use and development. *DOE*
- Safe Learning-Enabled Systems: Foster foundational research that leads to the design and implementation of safety-critical, ML-based systems in which non-compliance of safety properties can be avoided with very high probability. *NSF*
- Secure AI: Conduct foundational research on metrics and best practices to ensure that AI applications are secure and free from vulnerabilities. *NIST*
- Secure and Trustworthy Cyberspace: Protect and preserve growing social and economic benefits of cyber systems while ensuring security and privacy. *NSF*
- Software Verification and Validation: Develop verification and validation of autonomy software for aeronautics and human space exploration. *NASA*
- Supply Chain Security: Research into the risks hidden in the software tools used to build AI software. *DTRA*

5. Develop shared public datasets and environments for AI training and testing.

- Advanced Information Systems Technology: Develop AI and other IT for Earth Science and applications, including disaster response, and water resources. *NASA*
- Advancing Collaborative Connections for Earth System Science: Create benchmark training datasets to accelerate algorithm development. *NASA*
- AI Patent Dataset: Making datasets available to assist researchers and policymakers in focusing on the determinants and impacts of AI invention. *USPTO*
- Auto-ML: Develop ML tools to automate the creation of labeled datasets. *DHS*
- Battle Management and Advanced Guidance for Defense Against Hypersonic: Create advanced modeling and simulation framework to support hypersonic threat interception by developing battle management and advanced guidance and control algorithms based on differential game theory, continuous pursuit and evasion concepts, control theory, and optimization methods. *MDA*
- Computer Modeling and Epidemiology for Bio-preparedness and Response: Develop scientific capabilities that aid in the prevention and response to potential biothreats. *DOE/SC*
- Cyberinfrastructure for Sustained Scientific Innovation (CSSI): Integrated cyberinfrastructure services, quantitative metrics with targets for delivery and usage of these services, and AI resources. *NSF*
- Findable, Accessible, Interoperable, and Reusable (FAIR) Data and Models for AI and ML: AI research to facilitate the advancement of AI via data and models that are FAIR. *DOE/SC*
- Improve craniometric ancestry estimation with deep learning methods: Build prediction models to classify skulls of unknown ancestry to each of the six groups to match unknown individuals to missing persons. *NIJ*

- Investigator-initiated research into AI systems and platforms for biomedical research: Machine-Learning Opioid Prediction and Risk-Stratification E-Platform; Cloud-based, service-oriented, high-performance NLP Platform for Healthcare; a multivariate framework for biomarkers of mild cognitive impairment due to Alzheimer's disease; Federated Tumor Segmentation platform; A Scalable Platform for Exploring and Analyzing Whole Brain Tissue Cleared Images. *NIH*
 - Joint Automated Repository for Various Integrated Simulations: Automate materials discovery and optimization using classical force-field, density functional theory, ML calculations, and experiments. *NIST*
 - Mid-scale Research Infrastructure: Design and implementation of research infrastructure; *NSF*
 - Multi-Cloud Ecosystem: Develop cloud to train models, and develop analytics, which will enable large-scale data analytics and AI on sensitive and restricted data. *DHS*
 - National Ecological Observatory Network: A continental-scale platform for ecological research. *NSF*
 - Open Knowledge Networks: Support R&D for repositories that support broad public use cases and address national priorities, spanning science, engineering, health, and commerce. *NSF*
 - Patient-Centered Outcomes Research (PCOR): Using Machine Learning Techniques to Enable Health Information Exchange to Support COVID-19-Focused PCOR. *ONC*
 - Self-Organizing Maps: Generate low-dimensional representations of high-dimensional data. *DTRA*
 - Smart Manufacturing: Develop methods for generation and curation of AI training data. *NIST*
 - Synthetic Data: Create synthetic datasets for training AI/ML for airport screening. *DHS*
 - Trusted Spectrum Testing: Robust test processes and validated measurement data that is necessary to develop, evaluate, and deploy spectrum sharing technologies. *NIST*
- 6. Measure and evaluate AI technologies through standards and benchmarks.**
- AI standards development: Advance development of standards for AI data, performance evaluation, robustness, security, and privacy. *NIST, AI R&D IWG agencies*
 - Autonomy, integration, and testing. *Army, DAF, Navy, TRMC*
 - Autonomous Systems Test Capability: Provide lab-based simulations, hardware in the loop, and live testing with safety monitoring to test autonomous ground vehicles. *Army, Navy, TRMC*
 - Advanced technology evaluation: Assessment and evaluation of advanced technologies and concepts to enhance capabilities in scientific computing, AI, ML, and cybersecurity. *DOE/SC*
 - AI validation and evaluation: Develop prize challenges, test beds, and benchmark problems for validation and refinement of AI systems. *NIST*
 - Equity through AI. *ONC*
 - Investigator-initiated research into AI Standards: ML to predict incident Mild Cognitive Impairment using standard clinical measures. *NIH*

- Review and Revalidation of the First Step Act Risk Assessment Tool: Ongoing assessment of Prisoner Assessment Tool Targeting Estimated Risk and Needs. *NIJ*
- Smart Sampling Techniques: Develop data science and ML techniques for identifying shortcomings (e.g., where the underlying data is leading to bias in predictions) in ML training data for a specific application. *DTRA*

7. Better understand the national AI R&D workforce needs: Grow the AI R&D workforce to ensure America leads the AI innovation of the future. See the EdW PCA for education, training, and career development related activities.

8. Expand PPPs to accelerate advances in AI and strengthen the Nation's R&D ecosystem. See also Key Coordination Activities and Section 5.0 on the National AI Research Institutes.

- Mission-focused AI and data science challenges. *DOE, NASA, academic partners*
- Digital Assistants for Science and Engineering: Develop AI/ML-based digital assistants for use onboard for missions and on the ground for all facets of R&D. *NASA, Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) partners.*
- National Cybersecurity Center of Excellence (NCCoE): Demonstrate trustworthy AI capabilities. *NIST, academic and industry partners, state and local government partners*
- Resilient and Intelligent NextG Systems: Accelerate research that will have a significant impact on emerging wireless and mobile communication, networking, sensing, and computing systems. *DOD, NIST, NSF, industry partners*
- Regional Innovation Engines: Catalyze and foster innovation ecosystems across the U.S. to positively impact the economy within a geographic region, address societal challenges, and advance national competitiveness. *NSF, regional partnerships*
- SBIR U.S. Coast Guard Hoax Detection: Discerning hoaxes from distress calls using multi-modal approaches to inform watch stander decisions. *DHS*
- Silicon Valley Innovation Program (Securing Soft Target): Analyzing and integrating video streams from multiple sources. *DHS*

9. Establish a principled and coordinated approach to international collaboration in AI research.

- Accelerate adoption and improve resilience of autonomous and AI-enabled systems in contested environments with Australia and the United Kingdom (UK). *Army, DAF, Navy, OSD, international partners*
- Accelerated Data Analytics and Computing Institute: Memorandum of Understanding among DOE and high-performance computing organizations in Japan, Germany, Switzerland, Finland, and Australia for research in computing, data, and AI. *DOE/SC, international partners*
- Collaborative Research in Computational Neuroscience: International research and data-sharing research in AI that will advance the understanding of nervous system structure and function. *DOE, NIH, NSF, international partners*
- Responsible and Equitable AI: Dear Colleague Letter to bring together U.S. and Australian researchers on responsible and Equitable AI. *NSF, international partners*

- Development of metrics repository with Organization for Economic Cooperation and Development. *NIST, international partners*
- Development of a roadmap for AI risk management approaches with U.S.-E.U. Trade and Technology Council *NIST, international partners*
- Quadrilateral (Australia, India, Japan, and U.S.) Security Dialogue. *NIST, international partners*
- Bi-lateral Engagements on AI evaluation, AI Technical Standards, and AI Security. *NIST, international partners*
- Privacy-enhancing technologies prize challenges. *NIST, NSF, international partners*
- International Research Scientist Development Award: Support for Pedestrian Injuries and Deep Learning Study. *NIH, international partners*
- US-Japan Science and Technology Cooperation Program in High Energy Physics: Partnership between DOE/SC Lab and Japanese researchers in High Energy Physics. *DOE/SC, international partners*

3.2.1.2 Key Coordination Activities

- National AI Initiative Office: Leads interagency processes that advance AI policy and strategy for the United States Government. This includes developing updates to the National AI R&D Strategic Plan. *AI R&D IWG Agencies*
- Principal Investigator meetings: Review research, identify new applications and discuss S&T gaps and barriers. *DARPA, DHS, DOE, DOT, NASA, NIFA, NIH, NIJ, NIOSH, NIST, NSA, NSF*
- HHS AI Community of Practice: Share and develop best practices, build shared resources and tools, and promote understanding of AI. *ACL, AHRQ, CDC, CMS, FDA, HRSA, IHS, NIH, ONC, SAMHSA*
- Video and Image Analytics (VIA) team: Coordinate Federal VIA R&D across 30 participating agencies and foster a robust multisector ecosystem to support this rapidly developing research area. *DHS, FBI, FHWA, IARPA, NIJ, NIST, NSF*
- Aviation Safety Information Analysis and Sharing: Provide a repository of commercial flight-recorded data and safety reports, analyzed for safety incidents. *NASA, NTSB, industry partners*
- National AI Advisory Committee: Provide recommendations on U.S. AI competitiveness, the science around AI, AI workforce issues, AI opportunities for international cooperation, and AI opportunities for diverse geographic regions. *NIST, NAIIO; academic, non-profits, civil society, and industry partners*
- Space S&T Partnership Forum: Develop trusted autonomy technologies for use in space. *NASA, NRO, USSF*
- Federal AI Standards Coordinator: Work with government and industry to identify critical standards development activities, strategies, and gaps. *NIST, other agencies, industry partners*
- Science of Autonomy: Focus on multidisciplinary research topics in autonomy and interconnecting fields. *DOD, academic and industry partners*

3.3 Computing-Enabled Human Interaction, Communication, and Augmentation (CHuman) PCA

CHuman R&D advances the ability of individuals to interact with one another and with computing, communication, and information technologies; this includes R&D of human-to-human and human-to-machine interactions and collaborations, and the impacts on society.

Reporting Agencies: *AHRQ, CDC, CMS, DAF, NIJ, NASA, Navy, NIH, NIOSH, NIST, NOAA, NSF, ONC, USDA, VA*

3.3.1 Strategic Priorities and Associated Key Programs

Following are the CHuman PCA's strategic priorities and relevant programs.

1. Develop cohesive sociotechnical systems that support collaboration and innovation, including systems that help people manage, verify, and disseminate information online; systems that help teams, crowds, and organizations coordinate productively; and systems that integrate diverse human teams having knowledge of both constructive and malicious human behaviors with ubiquitous computing, networking, data analytic, and knowledge representation systems.

- Clinical Decision Support Innovation Collaborative (CDSiC). *AHRQ, CDC, CMS, FDA, NIH, ONC, VA*
- Produce evidence report to examine the mechanisms by which healthcare algorithms and algorithm-informed decision tools exacerbate or perpetuate racial or ethnic health and healthcare disparities in access to care, quality of care, and health outcomes. *AHRQ*
- Air You Wear Challenge Prize: Stimulate the R&D of processes and technologies that address outpatient issues associated with supplemental oxygen and provide key resources for regulatory, reimbursement, and commercialization strategies. *CMS, FDA, NIH, NSF*
- Smart and Connected Communities (S&CC): Accelerate creation of science and engineering (S&E) foundations to bring about new levels of economic opportunity and growth, safety and security, health and wellness, accessibility and inclusivity, and overall quality of life. *DOT, NSF, USDA*
- Smart Health and Biomedical Research in the Era of Artificial Intelligence and Advanced Data Science: Support interdisciplinary fundamental research to address issues in health, including improving patient access, reducing health disparities, and enhancing the usability of health tools and information. *NIH, NSF*
- Convergence Accelerator Track H (Enhancing Opportunities for Persons with Disabilities (PWDs)): Convene multi-disciplinary, multi-sector researchers, practitioners, and others toward use-inspired solutions to enhance quality of life and work access for PWDs. *NSF*
- Diver Augmented Visual Display System: Expand U.S. Navy diving helmet prototype that uses waveguide optical display technology to provide the diver with high-resolution color data and imagery (e.g., sonar, video, text messages, photos, schematics, and augmented reality overlays) during training and actual dive missions. *OUSD(R&E)*
- Explainable AI and Bias in AI Systems programs: Conduct foundational research to build trust in AI systems by improving explainability and transparency, avoiding bias, and preventing discrimination. *NIST*

- Human-Centered Computing: Integrate knowledge across disciplines (e.g., computing and social sciences), to design computing systems that amplify diverse humans' physical, cognitive, and social capabilities; and to assess benefits (and risks) of computing systems based on human, technical, and social factors. *NSF*
- Telehealth Test-to-Treat Program: Enable individuals in vulnerable communities to receive delivery of at-home SARS-CoV-2 tests and prescriptions, as appropriate, and use telehealth to consult a clinician. *NIH*
- Trustworthy and Responsible Artificial Intelligence Resource Center: Develop an online forum to support and operationalize the NIST AI Risk Management Framework and its accompanying playbook and provide centralized access to tools, metrics, technical documents, and other relevant resources. *NIST*
- Trustworthy Artificial Intelligence Evaluation: Develop an innovative evaluation testbed that measures and mitigates potential harms using the concepts of responsible AI that emphasizes human centricity, social responsibility, and sustainability. *NIST*
- Research on Emerging Technologies for Teaching and Learning: exploratory and synergistic research in emerging technologies (e.g., AI, robotics, and immersive or augmenting technologies) for teaching and learning in the future. *NSF*
- Science of Learning and Augmented Intelligence: develop fundamental knowledge about principles, processes, and mechanisms of learning and augmented intelligence—how human cognitive function can be augmented through interactions with others and technology. *NSF*
- Usability and Human Factors research: Understand and measure human interaction with information technology, providing guidance for better design and use. *NIST*
- U.S. Army Synthetic Training Environment Enhanced Learning for Readiness Project: Leverage Total Learning Architecture to enable personalized, data-driven, and technology-enabled lifelong learning across the *DOD, OUSD(R&E)*
- Clinical decision support (CDS) initiative: Assist health care providers move PCOR evidence into practice through CDS. *AHRQ, CDC, CMS, VA*
- Electronic care (eCare) Plan for people with multiple chronic conditions: Develop and test open-source, clinician-facing, patient-facing, and caregiver-facing SMART on Fast Healthcare Interoperability Resources eCare Plan applications as well as a Fast Healthcare Interoperability Resources eCare Plan implementation guide. *AHRQ, NIH*
- Center for Evidence and Practice Improvement Evidence Discovery and Retrieval Project: Apply FAIR data principles to patient-centered outcomes research findings within AHRQ repositories. *AHRQ*
- Care transition research grants: Fund research to produce evidence and evidence-based tools to improve care transitions. *AHRQ*
- Digital healthcare equity framework and guide: Produce a framework and guide that specifies the aspects that need to be considered when creating and planning equitable healthcare solutions that involve digital technologies. *AHRQ*
- Digital healthcare safety research grants: Fund research on safe digital healthcare practices specifically related to the design, implementation, usability, and safe use of digital healthcare by all users, including patients. *AHRQ*

2. Improve interfaces between humans and intelligent systems, including robots, virtual and conversational agents, autonomous vehicles, machine-learning systems, and other systems that exhibit intelligence and autonomy.

- Haystack: Develop Multilingual Multimedia Information Extraction and Retrieval based system which is accessed via a web browser. *AFRL, OUSD(R&E)*
- BATMAN: Develop a human-machine teaming interface for battlefield air operations and guardian angel operations toolkits for advanced wearables tailored to the Air Force's Special Operations/Personnel Recovery missions. *AFRL, OUSD(R&E)*
- Navy Actionable Information Tactical Applications Program: Produce a natural language query and process automated product generation, information discovery, workflow automation, and plan generation and assessment. *OUSDR&E)*
- Strengthening Teamwork for Robust Operations in Novel Groups: Develop the foundation for enhanced teamwork within heterogeneous human-intelligent agent teams using diverse, multidisciplinary expertise. *ARL, OUSD(R&E)*
- Augmented Reality Usability: Develop usability testing and usability analysis on augmented reality software solutions across wide range of applications. *NIST*
- Disability and Rehabilitation Engineering: Research technologies that support persons with disabilities by advancing knowledge on specific disability, pathological motion, or injury mechanisms. *NSF*
- Foundational Research in Robotics: Research robotic systems that exhibit significant levels of both computational capability and physical complexity. *NSF*
- Develop flexible, reconfigurable human-machine teaming for the U.S. Army's Modernization Priority Next Generation Combat Vehicle. *OUSDR&E)*
- Mind, Machine, and Motor Nexus: Integrate treatment of human intent, perception, and behavior in interaction with embodied and intelligent engineered systems and as mediated by motor manipulation. *NSF*
- Study interface and safety communication features of robots with collaborative functions, powered exoskeletons (i.e., wearable robots), and other interactive robots that may cause human injuries from sources such as unintended contact, collision, or vibration. *NIOSH*
- Study safe, intuitive, and useful robot technologies and engineering features of collaborative and co-existing robot systems for hazard exposure assessments, pathogen exposure control, field inspections, and incident investigations. *NIOSH*

3. Promote education and workforce development in human-IT interactions. In conjunction with investments in the EdW PCA, develop new instructional materials and teacher professional development models based on evolving educational and technological practices. See the EdW PCA for education, training, and career development related activities.

3.3.2 Key Coordination Activities

- CDS Innovation Collaborative: Monthly and quarterly meetings with multiple work groups focused on advancing interoperable, patient-centered CDS in real-world settings. *AHRQ, AHRQ grantees and contractors, Federal partners, healthcare system leaders, healthcare industry, patient and caregiver activists, standards experts*

- National Webinars: Recurring public national webinars on various health IT related topics. *AHRQ, AHRQ grantees, healthcare providers, digital healthcare researchers*
- Patient-reported outcomes (PRO) U18 learning collaborative: Annual meetings with U18 grantees to share and learn from each other's experience in using innovative health IT strategies to collect and use PRO data in ambulatory care settings. *AHRQ, U18 grantees*
- Solider Performance Application for Readiness and Talent Assessment: Score collective performance exercises in the Measuring and Advancing Soldier Tactical Readiness and Effectiveness program and U.S. Military Academy. *OUSD(R&E)*

3.4 Computing-Enabled Networked Physical Systems (CNPS) PCA

CNPS R&D advances systems that are complex, highly reliable, real-time, networked, and/or hybrid; this includes R&D in cyber-physical systems and the Internet of Things.

3.4.1 Computing-Enabled Networked Physical Systems IWG

Participating Agencies: *AFRL, AHRQ, Army CCDC, DARPA, DHS, DOD, DOE, DOT, FAA, FDA, FHWA, FMCSA, FTA, ITA, MARAD, NASA, NHTSA, NIFA, NIH, NIST, NRC, NSF, NTIA, ONR, OSEL, OUSD(R&E), State*

The CNPS IWG coordinates Federal R&D to advance and ensure integrated IT-enabled cyber, physical, and human systems. This spans complex, high-reliability, safety-security-critical, real-time computing and engineered systems with varying degrees of autonomy and human-system interaction in such uses as automated vehicles, smart grids, manufacturing, intelligent defense systems, and smart cities.

FY24 Administration Priorities: CNPS Examples

Reducing the Death Rate from Cancer By Half: Artificial Intelligence and Machine Learning Program - Research on AI/ML-Based Medical Devices

Development of regulatory science tools and methods to understand the performance of AI algorithms for cancer detection and classification. FDA.

(<https://www.fda.gov/medical-devices/medical-device-regulatory-science-research-programs-conducted-osel/artificial-intelligence-and-machine-learning-program-research-aiml-based-medical-devices>)

Advancing National Security and Technological Competitiveness: Operational Technology Control Systems Security

Cybersecurity guidance and best practices, and digital twins for trustworthy manufacturing, smart grid, chemical processing, water, transportation systems (rail), and other critical infrastructure applications. DHS, DOE.

Innovating for Equity: Smart Cities and Communities

Integrating best practices and measurement methods for equity, inclusion and trust in the design and implementation of smart cities and communities. NIST.

(<https://www.nist.gov/ctl/smart-connected-systems-division/iot-devices-and-infrastructures-group/smart-america/global>)

3.4.1.1 Strategic Priorities and Associated Key Programs

Following are the CNPS IWG's strategic priorities and relevant programs.

1. Develop core science and engineering for CNPS technologies including unified foundations, models and analysis tools, system capabilities, interoperability standards, assurance approaches, and architectures.

- Cyber-Physical Systems (CPS): Develop the core research needed to engineer complex CPS, some of which may also require dependable, high-confidence, or provable behaviors, such as control, data analytics, and machine learning including real-time learning for control, autonomy, design, Internet of Things (IoT), mixed initiatives including human-in- or human-on-the-loop, networking, privacy, real-time systems, safety, security, and verification. *DHS, DOT, NIFA, NIH, NSF*
- Agriculture and Food Research Foundational: Use data science to enable systems and communities to effectively utilize data, improve resource management, and integrate new technologies and approaches in U.S. food and agriculture enterprises. *NIFA, NSF*
- Advanced Air Mobility Mission Integration Office: Coordinate projects to research, test, and support aviation standards to enable safe, secure, interoperable, and efficient certification and operations of advanced air mobility systems. *NASA*
- Autonomy: Conduct research on autonomous systems, to enable the Navy to effectively operate while protecting our personnel. *ONR*
- Clinical and Translational Science: Develop innovative solutions that will improve the efficiency, quality, and impact of turning laboratory, clinic, and community observations into interventions that improve the health of individuals and the public. *NIH*
- Cloud Platform Interoperability Initiative: Connect NIH's various data systems to improve researchers' access to data and create a federated data ecosystem. *NIH, external partners*
- Genomics Research and Innovation Network: Globally scalable technology, policy, and procedures for sharing bio-samples and associated genomic and phenotypic data on broadly consented cohorts, across sites of care. *NIH*
- IoT systems engineering-based conceptual foundations, measurement and testing solutions, standards, and implementation practices for scalable, interoperable, and trustworthy IoT solutions. *NIST*
- Secure and Resilient CPS: Ensure CPS, such as ships and drones, are secure against cyber-attacks and resilient against failures of hardware and software. *ONR*
- Smart Grid Interoperability Profiles: Develop profiles of standards and guidelines for selected smart grid applications using consensus methods. *NIST*
- Space Technology Research Grants Program: Develop and demonstrate transformative smart autonomous habitats and related technologies that will adapt, absorb, and rapidly recover from expected and unexpected disruptions to deep space habitat systems without fundamental changes in function or sacrifices in safety. *NASA*
- Technology Demonstration Missions Program: Develop advanced computational simulation capabilities to enable reductions in ground-based and in-flight testing requirements, provide added physical insight, enable superior designs at reduced cost and risk, and open new frontiers in aerospace vehicle design and performance. *NASA*

2. Catalyze research and innovation of new and emerging ideas for CNPS to enable safety, security, resilience, and robustness spanning system design, development, assurance, verification, and maintenance of systems. Example innovations include applications of AI, digital twins, formal methods, and other concepts emerging from CNPS and related NITRD IWGs. Innovations and research will span multiple time horizons leading to new capabilities for complex intelligent systems, including to provide equitable societal resilience and robustness to climate change.

- CPS: Develop novel and foundational contributions for complex CPS that are both transformative and translational, demonstrating inventive new ideas and multi-disciplinary technical approaches to address societal challenges. Challenge applications range from highly focused inventions enabled by CPS technology to revolutionary approaches for next-generation infrastructures, and will address concerns such as agriculture, transportation, health, energy, and national security and will enable capability, adaptability, scalability, resiliency, safety, security, and usability that will expand horizons of complex CPS. *DHS, DOT, NIFA, NIH, NSF*
- Foundational Research Gaps and Future Directions for Digital Twins: Identify needs and opportunities to advance the mathematical, statistical, and computational foundations of digital twins in applications across science, medicine, engineering, and society. *DOD, DOE, NIH, NSF*
- Regulatory Science Research Program on AI and ML Devices: Ensure patient access to safe and effective AI and ML medical devices and develop robust test methods and tools for assessing AI and ML performance in pre-market and real-world settings to ensure safety and effectiveness. *CDRH, FDA, NIH, OSEL*
- National AI Research Institutes: Address challenges in methods, data, privacy, and fairness that advance foundational AI research and agriculture and food systems by addressing a wide range of research, building new multidisciplinary communities, and create the workforce needed for an AI-powered revolution in climate-smart agriculture. *NIFA, NSF*
- Foundational Research in Robotics: Research on robotic systems for agriculture that exhibit significant levels of both computational capability and physical complexity. *NIFA, NSF*
- Automated Vehicles Measurement Science: Develop infrastructure, test methods, and metrics for automated vehicles to advance system level measurement and testing for sensors and perception. *NIST*
- Automated Vulnerability Identification Prioritization for Embedded Resources: Develop semi-automated software assurance toolchain that will identify vulnerabilities in source and executable software. *AFRL*
- Autonomy: Conduct research on autonomous systems, which will enable us to effectively operate while protecting our personnel. *ONR*
- Deep Space Quantum Link: Develop the technology to perform pioneering experiments on gravitational effects on quantum systems, test the basic assumptions of quantum theory, and demonstrate Quantum key distribution at deep space distances. *NASA*
- Digital Transformation Network for Inflammatory Bowel Disease (IBD): Establish baseline levels of digital connectivity, disease control, quality of life, and care metrics in cohorts at the three IBD centers. *NIH*

- Foundational Research in Robotics: Support research on robotic systems that exhibit significant levels of computational capability and physical complexity. *NSF*
- Future Manufacturing cyber track. *NSF*
- Operational Technology (OT) Security: Expand industrial control systems cybersecurity guidance to OT security and resilience, and development of Cybersecurity for OT testbed(s) for R&D to support critical infrastructure sectors. *NIST*
- Optical Clock and Time Transfer Link in Space: Develop the technology to place a high-performance optical clock in space and develop a time and frequency link consistent with recent optical clock performance advances. *NASA*
- Safe Learning-Enabled Systems: Foster foundational research that leads to the design and implementation of safety-critical, ML-based systems in which non-compliance of safety properties can be avoided with very high probability. *NSF*
- Secure and Resilient Cyber-Physical Systems: Ensure CPS, such as ships and drones, are secure against cyber-attacks and resilient against hardware and software failures. *ONR*
- Smart Connected Systems: Enable innovation in IoT systems operations, agility, resilience, reliability, safety, security, and privacy in critical infrastructures such as IoT Smart Grid, Trustworthy Control Systems Smart Manufacturing, and Automated Vehicles. *NIST*
- Synthetic Biology: Microbial biomanufacturing in space: Develop BioNutrients, a platform technology that uses food microorganisms to enable on demand production of nutrients during long-duration missions. *NASA*
- Test Coverage Estimation for Max Operational Capability in Autonomous Systems: Calculus and Metrics for Quantifying Coverage of Autonomous Systems. Model-based Measurement of Test Coverage Quantification. *AFRL*
- Transformative Aeronautics Concepts Program: Develop next generation composite materials and manufacturing methods to support Urban Air Mobility, a safe and efficient air transportation system for on-demand mobility (e.g., small package delivery, air taxis). *NASA*

3. Support advances in smart cities and communities by investing in multidisciplinary, multisector research and innovation collaborations that leverage CNPS applications for solutions in areas such as public health and well-being, transportation and mobility, energy, smart infrastructure, agriculture and rural connectivity, emergency management, resilience, public safety, and water management. Research advances can include technology transfer to public and private systems in a manner that serves vulnerable and underserved communities, promotes equity, and addresses climate change.

- Cooperative Driving Automation Research: Leverage emerging capabilities in automation and cooperation to advance transportation systems management and operations strategies. *DOE, FHWA, FMCSA, FTA, MARAD, NHTSA*
- Cyber Physical Systems (CPS): Foster a research community that is committed to advancing education and outreach in CPS and to transitioning CPS research into the real world. *DHS, DOT, NIF, NIH, NSF*
- Civic Innovation Challenge: Fund ready-to-implement, research-based pilot projects with potential for scalable, sustainable, and transferable impact on community-identified priorities. *DOE, DHS, NSF*

- Smart and Connected Communities: Accelerate creation of scientific and engineering foundations to increase economic growth, safety and security, health and wellness, accessibility and inclusivity, and overall quality of life. *DOT, NIFA, NSF*
- Exploratory Advanced Research Program: Conduct long-term and high-risk research with the potential to transform the planning, building, renewing, and operating of safe, congestion free, and environmentally sound transportation systems. *FHWA, NSF*
- Automated Vehicle and Automated Driving Systems safety measurement methods for use by industry, facilitated by NIST-led working group with industry, academia, and government participation. *NIST, academic, industry, and government partners*
- Critical Agricultural Research and Extension: Address critical challenges and opportunities that research and extension, together, can address to improve our nation’s agricultural and food systems. *NIFA*
- Civil, Mechanical and Manufacturing Innovation Core Program: Support fundamental and innovative research in the design, operation and management of civil infrastructure that contributes to creating smart, sustainable and resilient communities at local, national, and international scales. *NSF*
- Design for Environmental Sustainability in Computing: Address the substantial environmental impacts that computing systems have through their entire lifecycle from design and manufacturing to deployment and operation, and into reuse, recycling, and disposal. *NSF*
- Innovative Technologies for Research on Climate Change and Human Health (SBIR/STTR – Clinical Trial Optional): Develop innovative tools, technologies, and methodologies on climate change and health that will significantly increase the potential for understanding the complex drivers of adverse health outcomes and enable effective interventions across multiple communities. *NIH*
- Investigator-initiated research in Next Generation Implantable Smart Cardiac Pacemakers: Enable smart pacemakers with energy efficiency that could reduce surgical replacement of these devices and the lower associated healthcare costs. *NIH*
- Investigator-initiated research on climate change and healthcare: Enable research to reduce the healthcare sector’s greenhouse gas emissions and carbon footprint. Create resilient healthcare systems and communities that can plan, prepare, respond, and adapt to climate-related threats, and address the inequitable impacts of climate change. *AHRQ*
- IoT-Enabled Smart Infrastructures: Research methods (including NIST smart cities and communities’ key performance indicator framework), identification of best practices (including through NIST Global Community Technology Challenge ecosystem), and collaborative multidisciplinary and multisector research partnerships to enable IoT at scale in interconnected smart infrastructures and multiple smart community applications (e.g., public safety communications, emergency management, and resilience). *NIST, OUSD(R&E)*
- Rapid Acceleration of Diagnostics – Underserved Populations (RADx-UP): Reduce COVID-19 associated morbidity and mortality disparities for those vulnerable and underserved populations who are disproportionately affected by, have the highest infection rates of, and/or are most at risk for adverse outcomes from contracting the virus. *NIH*
- Reliable smart grid communications. *NIST, OUSD(R&E)*

- Transformative Aeronautics Concepts Program: Establish an algorithmic foundation to support the development, deployment, and adoption of advanced air mobility systems for autonomous cargo operations at scale. *NASA*
- Transformative Aeronautics Concepts Program: Improve the quality of life of Americans by enabling point-to-point, on-demand air transportation in densely populated areas (e.g., air taxis with vertical takeoff and landing capability could revolutionize emergency medical services.) *NASA*

4. Promote inclusive education, training, and career development through curricula that integrates CNPS and by providing venues for communications and collaboration among scientists and researchers. See the EdW PCA for education, training, and career development related activities.

3.4.1.2 Key Coordination Activities

- CPS Program Principal Investigator Meeting: Collaborate with grantees from the program and Government agencies supporting the research. Previous year had more than 700 attendees. *DARPA, DHS, DOT, NIFA, NIH, NSF*
- S&CC Virtual Organization: Facilitate and foster collaboration and information exchange between S&CC researchers, communities, industry, and others. *DOT, NIST, NSF, State, USDA, academic partners*
- CIVIC Innovation Challenge: Multiple coordination meetings throughout the program including kick-off, community of practice, and final demonstrations. *DHS, DOE, DOT, NIFA, NSF*
- Digital Infrastructure: Development of a concept of operations for automated driving systems that describes likely uses that can safely, equitably, and efficiently be integrated with the overall transportation system. *DOE, FHWA, FTA, NHTSA, NIST*
- Joint Cyber Physical System Solicitation. *DHS, DOT, NIFA, NIH, NSF*
- Safety Assurance. *DARPA, NASA, NIST, NRC, NSF*
- Advanced Air Mobility: Development of multimodal and multidomain interdependencies. *FAA, FHWA, NASA*
- Automated Vehicles: Coordination and ongoing interactions on metrics and measurements to support development and testing of Automated Vehicles. *NHTSA, NIST, DOT*
- Joint CIVIC Innovation Challenge Solicitation. *DOE, DHS, NSF*
- Smart Cities and Communities (Global Community Technology Challenge): Coordination and collaboration to advance smart cities, including through public-private partnerships. *ITA, NIST, NTIA*
- Tools to Quantify and Assure Software Development Cycle: Increase software assurance via tools that aid in the design, development, automated testing and analysis, monitoring, assurance cases, and certification. Support Validation and Verification of Air Force embedded systems, including ones with learning-enabled components. *Army Combat (Army-CCDC), Army (GVSC), DARPA, OUSD(R&E)*

- Autonomous Amphibious Rescue Systems: Coordinate exploration of a joint, multi-agency effort to transform via agency technology transfers and common testbed, a retired Marine Amphibious Armored Vehicles into civilian autonomous amphibious search and rescue systems for hurricane, flood recoveries, national resiliency. *CNPS and IRAS IWG agencies*
- CPS Virtual Organization: Facilitate interaction and sharing of research artifacts across CPS and other programs including design tool suite and repository of CPS program presentations and PI meetings. *NSA, NSF*
- Joint CPS-related biomedical research. *NIH, NSF*
- International Collaborations
 - S&CC Principal Investigator Meeting: Bring together grantees and supporting Government agencies. Previous year had more than 500 virtual attendees for virtual participation. *DOT, NIFA, NIST, NSF, State, Japan Science & Technology*

3.5 Cyber Security and Privacy (CSP) PCA

CSP R&D advances the security and privacy of computing, communication, and information technologies; this includes R&D on how human behavior and usability interact with technical aspects of cybersecurity and privacy.

3.5.1 Cyber Security and Information Assurance (CSIA) IWG

Participating Agencies: AFRL, ARL, Army-C5ISR, DAF, DARPA, DHS, DOD/HPCMP, DOE/CESER, NIJ, NIH, NIST, NRL, NSA, NSF, ONR, OUSD(R&E), USCYBERCOM

The CSIA IWG coordinates Federal R&D to protect information, information systems, and people from cyber threats. This R&D supports the security and safety of U.S. information systems that underpin a vast array of capabilities and technologies in many sectors, including power generation, transportation, finance, healthcare, manufacturing, and national security.

FY24 Administration Priorities: CSIA Examples***Advancing National Security and Technological Competitiveness: NIST NCCOE***

Convenes private industry, government agencies, and academia to create practical, standards-based solutions that organizations of all types and sizes can use to protect their assets, people, and data. NIST, DHS, AFRL, U.S. Coast Guard, DOT.

(<https://www.nccoe.nist.gov/>)

Advancing National Security and Technological Competitiveness: Secure and Trustworthy Cyberspace Program

Supports research addressing cybersecurity and privacy, drawing on expertise in one or more of these areas: computing, communication and information sciences; engineering; economics; education; mathematics; statistics; and social and behavioral sciences. NSF.

(<https://new.nsf.gov/funding/opportunities/secure-trustworthy-cyberspace-sate>)

Advancing National Security and Technological Competitiveness: DOE Cybersecurity Program

Advances research, development, and deployment of technologies, tools, and techniques to reduce risks to the Nation's critical energy infrastructure posed by cyber and other emerging threats. DOE, DHS, NIST, DARPA, DOD.

(<https://www.energy.gov/ceser/cybersecurity>)

Cultivating an Equitable STEM Education, Engagement, and Workforce Ecosystem: NSA National Centers of Academic Excellence in Cybersecurity

A collaborative cybersecurity educational program with community colleges, colleges, and universities that establishes standards for cybersecurity curriculum and academic excellence, includes competency development among students and faculty, supports community outreach and leadership in professional development, and integrates cybersecurity practice within the institution across academic disciplines. NSA, DHS, FBI, NIST, NSF, DOD. (<https://www.nsa.gov/Academics/Centers-of-Academic-Excellence/>)

3.5.1.1 Strategic Priorities and Associated Key Programs:¹⁸ Defensive Capabilities (1–4) and Priority Areas (5–10)

Federal cybersecurity R&D is a substantial portfolio. This section provides thematic highlights of the main lines of research pursued by those programs, mapped against the CSIA strategic priorities. The programs are listed in the accompanying FY 2024 *Federal Cybersecurity R&D Strategic Plan Implementation Roadmap*.¹⁹

Following are the CSIA IWG's strategic priorities and relevant programs.

1. Deter: Develop methods to assess adversary levels of effort, results, and risks; provide for effective and timely attribution of malicious cyber activities to their sources; design robust investigative tools; and support information sharing for attribution.

- Cyber deception. *ARL, DHS, NSA, ONR, OUSD(R&E)*
- Automated, autonomous, and agile cyber defense. *ARL, NSA, NSF*

¹⁸ See Federal cybersecurity R&D priorities in <https://www.nitrd.gov/pubs/Federal-Cybersecurity-RD-Strategic-Plan-2019.pdf>

¹⁹ <https://www.nitrd.gov/pubs/FY2024-Cybersecurity-RD-Roadmap.pdf>

2. Protect: Develop technologies to limit system vulnerabilities through design, construction, and verification and to enforce security through techniques such as authentication, access control, and cryptography.

- Application, data, network, mobile, and hardware security. *AFRL, ARL, C5ISR, DARPA, DHS, DOE/CESER, NIH, NIST, NSA, NSF, ONR, OUSD(R&E)*
- Resilient cyber, cyber-physical, and IoT systems. *AFRL, ARL, C5ISR, DARPA, DHS, DOE/CESER, NIH, NIST, NSA, NSF, ONR*
- Automated and autonomous cyber defense and operations. *ARL, C5ISR, DHS, NSA, NSF, ONR, OUSD(R&E)*
- Assured systems. *AFRL, DARPA, NIST, NSA, NSF, ONR*
- Cryptography and formal analysis. *AFRL, DARPA, NIST, NSA, NSF*
- Risk and vulnerability management. *NIST, NSA, NSF*

3. Detect: Develop technologies to ensure that system owners and users have situational awareness and understanding of ongoing activities and can reliably detect malicious cyber activities.

- Cyber situational awareness. *ARL, C5ISR, DARPA, DHS, DOE/CESER, DOD/HPCMP, NSA, ONR, OUSD(R&E)*
- Cyber maneuver and resilience. *ARL*
- Information integrity. *NSF*

4. Respond: Develop technologies to provide real-time assessments of system anomalies, provide adaptive response to disruptions, sustain critical functions, and enable automated recovery.

- Autonomous, agile, and adaptive cyber response technologies. *AFRL, ARL, C5ISR, DHS, DOE/CESER, NSA, NSF, ONR, OUSD(R&E)*
- Countering cyber-attacks. *DHS, NIST, NSF*

5. Artificial Intelligence: Develop solutions that enable automated cyber defense, minimize susceptibility of AI systems to attacks, and ensure that AI systems are explainable.

- AI for cybersecurity. *ARL, C5ISR, DARPA, DHS, DOE/CESER, NIH, NIST, NSA, NSF, ONR, OUSD(R&E)*
- Cybersecurity of AI. *ARL, C5ISR, DHS, NIST, NSA, NSF*
- Standards for AI. *NIST*

6. Quantum Information Science (QIS): Develop technologies for securing quantum software and hardware and for developing countermeasures against quantum-based attacks.

- Quantum science, programming, and protocols. *AFRL, ARL, C5ISR, DOE/CESER, DHS, NIH, NSF*
- Quantum-resistant cryptography. *NIST, NSF*

7. Trustworthy Distributed Digital Infrastructure: Develop technologies to provide secure and resilient communication and computing infrastructures that incorporate advanced wireless, cloud computing, IoT, and CPS resources.

- Wireless and network security. *AFRL, ARL, C5ISR, DARPA, DHS, DOE/CESER, NIST, NSA, NSF, OSD, OUSD(R&E)*
- Protection of cyber-physical and IoT systems. *AFRL, DARPA, DHS, DOE/CESER, NSA, NSF, ONR*

8. Privacy: Develop solutions to enable privacy-protecting data processing and analytics and to provide for recovery from privacy violations. See also the Privacy R&D IWG.

- Privacy-enhancing technologies. *DHS, NIST, NIH, NSF*
- Privacy Framework: Help organizations build better privacy foundations by bringing privacy risk into parity with their broader enterprise risk portfolio. *NIST*

9. Secure Hardware and Software: Develop technologies to ensure that the design and operation of IT hardware and software can be verifiably trusted and cannot be maliciously compromised.

- Software assurance. *AFRL, DARPA, DHS, DOE/CESER, NIH, NIST, NSA, NSF, ONR*
- Formal verification of software and hardware. *AFRL, DARPA, NIST, NSF, NSA, ONR*
- Secure microprocessors and IoT. *AFRL, DHS, NSA, NSF*

10. Education and Workforce Development: Develop and accelerate adoption of effective educational programs to prepare the Nation, at all education levels and in all sectors of society, for possible careers in cybersecurity and for safe and secure use of cyberspace. See the EdW PCA for education, training, and career development related activities.

3.5.1.2 Key Coordination Activities

- Federal Cybersecurity R&D Strategic Plan Implementation Roadmap: Provide annually as directed by Cybersecurity Enhancement Act of 2014. *All CSIA IWG agencies*
- DOD Reliance 21 Cyber Community of Interest: Provide oversight and coordination among DOD cyber S&T programs. *AFRL, ARL, C5ISR, DARPA, NSA, ONR, OUSD(R&E), USCYBERCOM*
- National Centers of Academic Excellence in Cybersecurity: Reduce vulnerability in national information infrastructure by promoting higher education and expertise in cybersecurity. *DHS, NIST, NSA, NSF, USCYBERCOM*
- Cyber technology demonstrations. *DARPA, NIST, NSA, OUSD(R&E)*
- Cyber Security Collaborative Research Alliance: Develop fundamental understanding of cyber phenomena, including aspects of human attackers, cyber defenders, and end users, so that fundamental laws, theories, and theoretically grounded and empirically validated models can be applied to broad range of Army domains, applications, and environments. *ARL, C5ISR, academic and industry partners*
- Advanced Course in Engineering: Cybersecurity classes. *AFRL, NSA*
- Cryptographic standards development. *NIST, NSA*

- Cyber and cyber-physical security public working groups. *NIST, academic and industry partners*
- Standards development: Engage with national and international bodies (e.g., 3rd Generation Partnership Project, Internet Engineering Task Force, International Organization for Standardization, American National Standards Institute (ANSI), Institute of Electrical and Electronics Engineers (IEEE)) in developing and setting cybersecurity standards. *NIST, NSA*
- National Initiative for Cybersecurity Education (NICE) and annual NICE Conference and Expo: Lead robust multisector ecosystem for education and training, promotion of careers, and sustained development of diverse skilled workforce in cybersecurity. *NIST, community and interagency coordinating councils*
- NCCoE: Bring together experts from industry, government, and academia to address real-world needs of securing complex IT systems and protecting Nation’s critical infrastructure. *NIST, academic and industry partners, state and local government partners*
- International Collaborations
 - The Technical Cooperation Program: Command, Control, Communications, Cyber, Information Systems Group with Australia, Canada, New Zealand, and the United Kingdom. *AFRL, ARL, C5ISR, NSA, ONR, OUSD(R&E), international partners*
 - Science programs with Czech Republic, Germany, Ireland, and Israel. *NSF, OUSD(R&E), international partners*
 - Cyber Research, Prototyping, and Transition of Capability Steering Group: Develop world-class cyber capabilities while ensuring that different organizations can work seamlessly together by using technology, insights, and activities to support shared objectives in cyberspace as part of Cyber Management Review forum. *AFRL, ARL, NRL, NSA, OUSD(R&E), USCYBERCOM, Defense Science and Technology Laboratory (UK-Dstl)*
 - Binational Industrial R&D Cyber: Enhance the cyber resilience of critical infrastructure in the United States and Israel by developing advanced cybersecurity applications for mission-critical homeland security needs. *DHS, Israel National Cyber Directorate*

3.5.2 Privacy Research and Development IWG

Participating Agencies: CDC, Census, DARPA, DHS, DOE/SC, DOL, DOT, ED, FTC, GSA, ODNI, NIH, NIST, NSF, State, VA

The Privacy R&D IWG coordinates Federal R&D aimed at preventing adverse privacy effects arising from information processing, including R&D of privacy-preserving information systems and standards. This R&D supports advances in large-scale data analytics that can improve healthcare, eliminate barriers to education and employment, and increase efficiencies in the transportation and financial sectors while minimizing risks to individual privacy and possible harms such as discrimination, loss of autonomy, and economic losses.

3.5.2.1 Strategic Priorities and Associated Key Programs

Following are the Privacy R&D IWG's strategic priorities and relevant topics.

1. Understand privacy desires and impacts.

- Develop models and conduct studies to understand peoples' privacy needs in different contexts. *Census, NIH, NIST, NSF*

2. Develop system design methods that incorporate privacy requirements and controls.

- Develop practical approaches for implementing privacy protections in data analytics systems. *Census, NIH, NIST, NSF*
- Provide methods for secure, privacy-preserving access to precision health data. *NIH, NSF*
- Develop privacy framework and standards-based tools and privacy engineering practices. *NIST*

3. Develop techniques to ensure that information use is consistent with privacy rules.

- Develop access control and encryption solutions for privacy protection. *NIH, NIST, NSF*
- Determine privacy engineering and technical standards for privacy. *NIST*

4. Develop solutions to enable user-driven controls and actions over data collection, use, and deletion.

- Advance data sharing for research under patient and research participant consent. *NIH, NSF*
- Protect privacy in networking, mobile computing, and the Internet of Things. *NIST, NSF*

5. Develop solutions for minimizing privacy risks while maximizing utility of data analytics.

- Develop secure and private collaboration environments. *Census, NIH, NSF*
- Develop techniques to ensure privacy protections in analytical and ML systems. *NIH, NIST, NSF*
- Develop privacy enhancing cryptography. *NIST, NSF*

6. Develop solutions for recovery from privacy violations.

- Develop techniques to mitigate privacy violations and support privacy recovery. *NIST, NSF*

3.5.2.2 Key Coordination Activities

- NIST Privacy Engineering Collaboration Space: Actively support this online forum for sharing use cases and tools to advance privacy engineering. *All Privacy R&D IWG agencies*
- Privacy Preserving Technologies: Technologies to maximize their benefits in an equitable manner, promote trust, and mitigate risks. *CDC, Census, DARPA, DHS, DOE, DOT, ED, GSA, HHS, NIH, NIST, NSF, NTIA, ODNI, State, VA*
- Privacy Research Workshops: Host annual workshops on topics such as privacy controls, privacy framework, algorithmic transparency, and consumer privacy protections. *FTC, NIH, NIST, NSF*
- Federal Privacy Council: Participate actively in this interagency forum organized to improve privacy practices of Federal agencies. *FTC, NIST, NSF*

- Challenges: iDASH Secure Genome Analysis Competition, competition in privacy-preserving analytics utilizing biomedical data. *NIH, academic and industry partners*
- NIST Privacy Framework: Continue collaboration on framework implementation and development of related guidelines and tools. *Federal agencies, private sector partners*
- Technical privacy guidelines: Develop and coordinate recommendations, guidelines, and standards for privacy-preserving technologies and privacy risk assessment methodologies. *Census, NIST*
- International collaborations
 - Prize challenges in privacy-enhancing technologies: Engage Federal agencies and domestic and international stakeholders in developing innovative privacy-enhancing technologies. *NIST, NSF, international partners*
 - Engage in international privacy standards development. *NIST, international partners*

3.6 Education and Workforce (EdW) PCA

EdW R&D advances the use of computing, communication, and information technologies to enhance education and workforce training at all levels; this includes the recruitment, preparation, and retention of a diverse population of researchers, entrepreneurs, and users; and support for learning, teaching, assessment, standards, and virtual education and training.

Reporting Agencies: *DAF, AFRL DARPA, DHS, DOE/CESER, DOE/NNSA, DOE/SC, NIJ, DOT, FHWA, NAIIO, NIFA, NIH, NIST, NOAA, NSF, ONR*

3.6.1 Strategic Priorities and Associated Key Programs

Following are the EdW PCA's strategic priorities and relevant programs.²⁰

Note: Investments for some of these programs are reported under other PCAs but are collected here to emphasize the importance of STEM education and workforce development.

1. Ensure a consistent flow of skilled workers capable of using the tools and methods of the economy of the future by creating opportunities to teach and learn computational literacy and computational thinking at all educational levels. Opportunities must span multiple STEM and IT domains; actively support diversity and inclusion; and include internships, fellowships, and early-career research opportunities.

- Computational Science Graduate Fellowship Program: Provide opportunities to students pursuing doctoral degrees in fields that use high-performance computing to solve complex S&E problems. *DOE/NNSA, DOE/SC*
- Women in IT Networking at Supercomputing Conference: Program for addressing prevalent gender gap that exists in in the fields of network engineering and high-performance computing. *DOE/SC, NSF*
- CyberForce Competition[®]: Host scenario-based collegiate competitions, with real-world anomalies and constraints, and interaction with users of the systems. *DOE/CESER, DOE National Laboratories*

²⁰ Note: Investments for some of these programs are reported under other PCAs but are collected here to emphasize the importance of STEM education and workforce development.

- DARPA Young Faculty Award: Engage rising stars in junior research positions, emphasizing those without prior DARPA funding, and expose them to DOD needs and DARPA's program development process. *DARPA*
- Informatics Technology for Cancer Research Education Resource for educational activities that will help cancer researchers to enhance the use and usability of the informatics tools and other resources developed and supported the NCI's Informatics Technology program. *NIH*
- Minority Educational Institution Student Partnership Program Internships: Provide professional and technical career experience while working side-by-side with an assigned mentor who is a DOE subject matter expert. *DOE/CESER*
- Quantitative and Computational Biology Graduate Training Program. *NIH*
- Training in Biomedical Informatics programs. *NIH*
- University-Based Cybersecurity R&D Centers: Collaborate to develop and build a system of cybersecurity education programs through hands-on R&D to improve and train the nation's energy sector workforce by ensuring a consistent flow of skilled workers. *DOE/CESER*
- Computer and Information Science and Engineering (CISE) Graduate Fellowships: Increase the number and diversity of domestic graduate students pursuing research and innovation careers in computer science, computer engineering, or information science. *NSF*
- CyberCorps® Scholarship for Service: Increase quantity of new entrants to government cyber workforce, increase national capacity for education of cybersecurity professionals, increase national R&D capabilities in critical information infrastructure protection, and strengthen partnerships between institutions of higher education and relevant employment sectors. *NSF*
- NSF Research Traineeship program: Provide graduate students with specialized training and funding assistance to follow careers at forefront of technology and innovation. *NSF*
- Entrepreneurial Fellowships program: Support scientists and engineers from a variety of backgrounds and regions across the U.S. to translate research breakthroughs to new products and services with broad societal benefits. *NSF*
- Experiential Learning in Emerging and Novel Technologies (ExLENT): Enable inclusive experiential learning opportunities designed to provide cohorts of diverse learners with the crucial skills needed to succeed in emerging technology fields and prepare them to enter the workforce ready to solve our Nation's most pressing scientific and societal challenges. *NSF*
- Faculty Early Career Development Program: Support early career faculty who have potential to serve as academic role models in research and education and to lead advances in the mission of their department or organization. *NSF*
- CISE Research Initiation Initiative: Support research independence among early-career academicians who specifically lack access to adequate organizational or other resources. *NSF*
- Research Education for Undergraduates: Support active research participation by undergraduate students in areas of NSF-funded research. *NSF*
- Partnerships for Research and Education in Materials: Enable, build, and grow partnerships between Minority-Serving Institutions (MSIs) and NSF-supported centers or facilities to increase recruitment, retention, and degree attainment by those most underrepresented in materials research. *NSF*

2. Prepare all Americans, through computational thinking and literacy lifelong learning programs in the workplace and community, to successfully participate in the economy and society of the future.

- Clinical guidance software for nurse education and practitioners to evaluate experiential case-files for the purpose of augmenting health disparity/equity clinical care. *NIH*
- Computer Science for All: Researcher-Practitioner Partnership: Focus on researcher-practitioner partnerships that foster R&D needed to bring computer science and computational thinking to all schools. *NSF*
- Consequence-driven, Cyber-informed Engineering (CCE):²¹ Engineering effort to eliminate inherent “trust” assumptions of technology and fill existing cybersecurity gaps through strategic changes in technology, process, and procedures. Provide continued Federal workforce development through CCE Boot Camp training and sector outreach through Accelerate training. *DOE/CESER*
- CyberStrike Training: Hands-on energy sector industrial control systems workshop to help owners and operators understand, identify, and prepare for sophisticated cyber incidents. *DOE/CESER*
- Operational Technology (OT) Defender Fellowship Program: Elite training program for OT security managers to better understand the cyber strategies and tactics adversaries use to target U.S. energy infrastructure. *DOE/CESER*
- Research Experiences for Teachers in Engineering and Computer Science: Support summer research experiences for K–14 educators to foster long-term collaborations between universities, community colleges, school districts, and industry partners. *NSF*
- Scalable multi-mode education to increase use of tools by developing and releasing a software platform for rapidly prototyping, validating, and sharing modular training materials to a broad community ranging from citizen scientists to cancer researchers. *NIH*

3. Promote coordination and collaboration among Federal agencies and business, educational, and nonprofit communities to develop a persistent and robust U.S. IT education ecosystem including educational programs, tools, and technologies.

- Broadening Participation in Computing: Increase number of U.S. citizens and permanent residents receiving post-secondary degrees in computing disciplines and encourage participation of all underrepresented groups in those disciplines. *NSF*
- Research on Emerging Technologies for Teaching and Learning: Fund exploratory and synergistic research in emerging technologies (e.g., AI, robotics, and immersive or augmenting technologies) for teaching and learning. *NSF*

4. Develop the current and future HEC workforce for both R&D and infrastructure and application. See also the EHCS PCA.

- Research opportunities that advance the knowledge and use of advanced computing: Computational Science Graduate Fellowship. *DOE/NNSA, DOE/SC*
- High Performance Computing Internship Program. *Army*
- Faculty Immersion Experience. *Army*

²¹ https://www.energy.gov/sites/default/files/2022-06/FINAL%20DOE%20National%20CIE%20Strategy%20-%20June%202022_0.pdf

- Predictive Science Academic Alliance Program. *DOE/NNSA*
- Research Education for Undergraduates; Training-based Workforce Development for Advanced Cyberinfrastructure. *NSF*
- Reaching a New Energy Sciences Workforce (RENEW) Initiative. *DOE/SC*
- Funding for Accelerated, Inclusive Research. *DOE/SC*
- Summer High School Internship Program. *NIST*
- Summer Undergraduate Fellowship Program. *NIST*
- National Research Council (NRC) Postdoctoral Associateship Program. *NIST*
- Professional Research Experience Program. *NIST*
- Variety of internships, including outreach of MSIs. *NOAA*
- Diversity and Inclusion Policy across the entire NOAA workforce, including bias training, mentorship programs, and hiring initiatives. *NOAA*
- Engagement with the STEM community to broaden impact:
 - Hackathons, tutorials, and workshops. *NASA*
 - Open Data Science Gateway for the DS-I Africa consortium. *NIH*
 - Research Coordination Networks: Fostering and Nurturing a Diverse Community of CI Professionals. *NSF*
 - Computer and Information Science (CISE) Education and Workforce Program. *NSF*

5. Build a diverse multigeneration workforce necessary to develop, support, and use all aspects of big data. See also the LSDMA PCA.

- CISE Minority-Serving Institutions Research Expansion Program: Broaden participation by increasing number of CISE-funded research projects from MSIs and develop research capacity toward successful submissions to core CISE programs. *NSF*
- Computing Research Association: Strengthen research and advanced education in computing and allied fields. *DOE/SC*
- Data Science Corps to provide practical experiences, teach new skills, and offer teaching opportunities to data scientists and data science students. *NSF*
- CyberTraining: Training-based Workforce Development for Advanced Cyberinfrastructure to prepare, nurture, and grow the national scientific research workforce. *NSF*
- NSF Research Traineeship: Encourage the development and implementation of transformative models for STEM graduate education training, including a focus on data. *NSF*
- Data and Technology Advancement National Service Scholar Program: Bring data and computer scientists and engineers to tackle challenging biomedical data problems. *NIH*
- National Network of Libraries of Medicine: Provide access to and use of biomedical and health information resources through robust exhibition, and educational materials assistance with creating data management plans and helping scientific researchers find appropriate data repositories to submit their data through an innovative tiered educational model. *NIH*
- Office of Science Early Career Research Program: Support individual research programs of outstanding early career scientists. *DOE/SC*

- RENEW: Provide undergraduate and graduate training opportunities for students and academic institutions not currently well represented in the U.S. S&T enterprise. *DOE/SC*
- Funding for Accelerated, Inclusive Research: Build research capacity, infrastructure, and expertise at MSIs. *DOE/SC*
- Computing Research Association for career development and outreach workshops. *DOE/SC*
- Office of Science Early Career Research Program for support of exceptional early career researchers. *DOE/SC*
- Computational Sciences Graduate Fellowship. *DOE/SC*
- Research Training Initiative for Student Enhancement Program: Provide support for academic institutions to develop training opportunities with research experience and course development (in areas such as data science, computational biology, and AI/ML) with a focus on enhancing a diverse workforce. *NIH*
- Training Grants for Research Training in Biomedical Informatics and Data Science. Provide support for predoctoral and postdoctoral training for research careers in biomedical informatics and data science. *NIH*

6. Better understand the national AI R&D workforce needs: Grow the AI R&D workforce to ensure America leads the AI innovation of the future. See also the AI R&D PCA.

- Workforce education, development, and upskilling. *DAF, DOD, DOE/NNSA, DOE/SC, NAIIO*
- Agriculture and Food Research Initiative (AFRI) Food and Agricultural Non-Formal Education: Build the institutional teaching, research, and extension capacities of the eligible institutions through cooperative programs with Federal and non-Federal entities. *NIFA*
- AFRI Research and Extension Experiences for Undergraduates: Promotes research and extension learning experiences for undergraduates such that upon graduation they may enter the agricultural workforce with exceptional skills. *NIFA*
- 1890 Institution Teaching, Research and Extension Capacity Building Grants Program: Build the institutional teaching, research, and extension capacities of the eligible institutions through cooperative programs with Federal and non-Federal entities. *NIFA*
- AI and Technology Collaborations or Aging Research: Develop training activities for AI and technology for scientists, engineers, clinicians and other medical professionals, patients, policy makers, and investors. *NIH*
- Computing in Undergraduate Education: Support re-envisioning how to teach computing effectively to a broad group of students, in a scalable manner, with an emphasis on broadening participation of groups who are underrepresented and underserved by traditional computing courses and careers. *NSF*
- Law Enforcement Advancing Data and Science Scholars Program: Criminal justice practitioner focused outreach. *NIJ*
- Cyber Resilience of Substations for Grid Operation and Control: Uses AI and ML for threat detection in substations. *DOE/CESER, academic partner*
- AI Frontier Data Lab Challenge to combat wildfires. *DOE/CESER, DOE/SC*
- Applied-AI for Clean Energy and Infrastructure Resilience. *DOE/CESER*

- Expand AI; CSGrads4US; Computer Science for All. *NSF*
- Expanding AI Innovation through Capacity Building and Partnerships: Supports capacity-development projects and partnerships within the National AI Research Institutes ecosystem that help broaden participation in AI research, education, and workforce development. *NSF*
- Early Career Research Program: Funding opportunity for early-career researchers in universities and DOE national laboratories, with topics in AI. *DOE/SC*
- Advanced Scientific Computing Research – Reaching a New Energy Sciences Workforce (ASCR-RENEW): Funding opportunity to build foundations for Office of Science (SC) research and training at institutions historically underrepresented in the SC research portfolio, with topics in AI. *DOE/SC*
- Research Associateship Program: Provides postdoctoral scientists and engineers of unusual ability and promise an opportunity to conduct research on problems that are compatible with the research interests of FHWA. *FHWA*
- Transforming Analytical Learning in the Era of Big Data Summer Institute Program. *NIH*

7. Develop the current and future SPSQ workforce by supporting STEM education and training; by supplying and sustaining the necessary resources such as software libraries, tools, and platforms to support teaching and research; and by advancing software proficiency and development capabilities in government organizations and government-led projects. See also the SPSQ PCA.

- Historically Black Colleges and Universities (HBCUs) and MSIs Programs: Support research at HBCUs and MSIs. *ONR*
- Naval STEM: Support training and workforce development in a wide range of technical areas, including cyber activities from Pre-K into post-doctoral activities. *ONR*
- Research Infrastructure Development for Interdisciplinary Aging Studies: Support shared infrastructure for cognitive assessment in the service of cognitive training research. *NIH*
- Secure and Trustworthy Cyberspace (SaTC) Program. *NSF*
- Software and Hardware Foundations Program. *NSF*

8. Promote inclusive education, training, and career development through curricula that integrates CNPS and by providing venues for communications and collaboration among scientists and researchers. See also the CNPS PCA.

- AFRI Education and Community Development: Focus on professional development, education, and workforce development, including development of a technology- and data-savvy workforce ready for the field and industrial jobs within food and agricultural sciences. *NIFA*
- Autonomous Software Security Vulnerability Testing based on Machine Learning and Artificial Intelligence: Develop Generative Adversarial Network based vulnerability detection methods trained on the Python datasets. *AFRL*
- Directorate for STEM Education research programs. Develop a well-informed citizenry and a diverse and capable workforce of scientists, technicians, engineers, mathematicians, and educators. Invests in activities aimed to improve knowledge of accessibility, integration, and adaptability in STEM education. *NSF*

- Education and Workforce Program: Ensure the development of a diverse workforce well prepared for careers in computing-related and computationally intensive fields. *NSF*
- Evaluating Assurance of AI-Enabled Classifiers: Ensure intelligent system has integrity and security assurance that are valid, verifiable, data-driven, robust, trustworthy, explainable to a layperson, ethical in the context of its deployment, unbiased in its learning, and usable and accessible to its users. *AFRL*
- HBCUs and MSIs Program: Supports research at HBCUs and MSIs. *ONR*
- Leverage NIST student hiring programs such as the Summer Undergraduate Research Fellowship, Pathways, and NRC post-docs to advance CNPS-related research. *NIST*
- Minority Leaders Research Collaboration Program: Enable, enhance, and expand the research capabilities of HBCUs and MSIs through collaborative research efforts. *AFRL*
- NICE: Energize and promote a robust network and an ecosystem of cybersecurity education, training, and workforce development. *NIST*
- Naval STEM Program: Supports training and workforce development in a wide range of technical areas, including cyber. *ONR*
- Research Associateship Program: Provide highly skilled and exceedingly promising postdoctoral and senior scientists and engineers with opportunities to research problems that are compatible with the interests of sponsoring laboratories including support for Cooperative Driving Automation. *FHWA*
- Virtual Reality (VR)-based Intelligent Orientation and Mobility Specialists: Provide a VR based program for assisting patients with low vision to move, communicate, and collaborate better. *NIH*

9. Promote education and workforce development in human-IT interactions. In conjunction with investments in the EdW PCA, develop new instructional materials and teacher professional development models based on evolving educational and technological practices.

- Evaluate inclusive training that helps workers acquire skills, knowledge, and abilities needed to operate rapidly advancing robots in complex and dynamic industrial environments. *NIOSH*
- Explore robotics technology and practice education for populations with disadvantaged resources and evaluate the impact of education and training of robotics to improve worker safety and health equity, considering culture, age, and education factors. *NIOSH*
- NIST Phish Scale: Allow organizations to better categorize actual threats (for better detection) and to better determine effectiveness of their phishing training programs. *NIST*
- Operational Partner to Interactively Manage Uninhabited System Procedures and Responses in Multi-Emergencies: Train air vehicle operators to better understand and react to emergency management fault codes, potentially avoiding mortality and injury. *Navy, OUSD(R&E)*
- VR Parachute Simulator Descent Trainer and Immersive Parachute Descent Procedure, Malfunction, and Decision-Making Training System: Enable parachute jumpers to hone their skills and plan missions on the ground before they take to the air. *Navy, OUSD(R&E)*

- Usable Cybersecurity: Conduct research based on human factors, human-computer interaction, cognitive psychology, and cybersecurity to provide actionable guidance for policymakers, system engineers, and security professionals to incorporate usability into their cybersecurity decisions, processes, and products. *NIST*

10. Develop the future micro- and nanoelectronics workforce, including across all parts of the research and innovation ecosystem. See also the ENIT PCA.

- JUMP 2.0: Fund fundamental electronics research at seven microelectronics research centers spanning 39 Universities involving hundreds of graduate students. *DARPA, academic and industry partners*
- Microelectronics Commons Workforce Development Thrust:²² Develop a pipeline of talent to bolster local semiconductor economies and contribute more broadly to the growth of a domestic semiconductor workforce. *OUSD(R&E)*
- Trusted and Assured Microelectronics Program Education and Workforce Development: Attract, develop, and maintain a skilled, clearable technical workforce to support design, development, fabrication, verification, validation, security, and modernization of microelectronics. *OUSD(R&E)*

3.7 Electronics for Networking and Information Technology (ENIT) PCA

ENIT R&D advances micro- and nanoelectronics design, architecture, validation, and testing across the networking and information technology hardware design stack; this includes methodologies for scalable and energy-efficient systems, silicon and/or non-silicon technologies, and implementations in computing and communication architectures.

Reporting Agencies: AFRL, ARL, Army, Census, DAF, DARPA, DHS, DOC, DOD, DOE/EERE, DOE/NSA, DOE/SC, FBI, IARPA, ODNI, NASA, Navy, NIH, NIST, NOAA, NRL, NRO, NSA, NSF, OSTP, OUSD(R&E), State, USGS

3.7.1 Strategic Priorities and Associated Key Programs

Following are the ENIT PCA's strategic priorities and relevant programs.

1. Foster innovative micro- and nanoelectronics designs, architectures, and methodologies that advance novel, scalable, and energy-efficient computing and communication technologies and systems.

- Microelectronics Commons Applied Research and Advanced Technology Development: Address the challenges of sustaining U.S. technological dominance through the growth of a robust domestic innovation ecosystem that fosters rapid translation of microelectronics technologies from laboratory to fabrication domestically; Support the development of processes, architectures, materials, and devices; Provide for assured access to next-generation microelectronics technology; Mitigate the threat to U.S. chip innovation. *OUSD(R&E)*
- Future of Semiconductors: Cultivate a broad coalition of researchers and educators from across S&E communities that utilizes a holistic, co-design approach to fundamental research to enable rapid progress in new semiconductor technologies. *NSF*

²² This workforce thrust represents 5% of overall Commons effort and is beyond the workforce and graduate students supported within individual R&D projects.

- CISE Core Programs: Support research and education projects that develop new knowledge in all aspects of computing, communications, information S&E, and advanced cyberinfrastructure. *NSF*
- Supplements for Access to Semiconductor Fabrication: Support fabrication of research devices and systems through standard semiconductor fabrication facilities. *NSF*
- Designing Materials to Revolutionize and Engineer Our Future: Control material properties through design by understanding interrelationships of composition, processing, structure, properties, performance, and process control. *NSF*
- Electronics, Photonics, and Magnetic Devices: Support innovative research on novel devices based on principles of electronics, optics and photonics, optoelectronics, magnetics, opto- and electromechanics, electromagnetics, and related physical phenomena. *NSF*
- Materials Innovation Platform: Accelerate advances in materials research. *NSF*
- Electronics Resurgence Initiative (ERI): Ensure U.S. leadership in cross-functional, next-generation microelectronics research, development, and manufacturing (over two dozen programs across seven thrust areas, including increasing processing density and efficiency, accelerating innovation in AI hardware to make decisions at the edge faster, manufacturing complex 3D microsystems, optimizing design and test for complex circuits and prototypes, and securing communications.) *DARPA*

2. Improve hardware integrity and security for next-generation secure computing and communications technologies and systems.

- ERI: Research dedicated to hardware security (i.e., overcoming security threats across the entire hardware lifecycle.) *DARPA*
- Secure and Trustworthy Cyberspace: Protect and preserve growing social and economic benefits of cyber systems while ensuring security and privacy. *NSF*

3. Develop the future micro- and nanoelectronics workforce, including across all parts of the research and innovation ecosystem. See the EdW PCA for education, training, and career development related activities.

4. Facilitate technology transfer and commercialization.

- Embedded Entrepreneurship Initiative: Provide catalytic funding, mentorship, and investor and corporate connections for DARPA researchers. *DARPA*
- ERI: Develop disruptive electronics technologies for dual-use technologies with an emphasis on manufacturing, transition, and commercialization. *DARPA*
- Industry-University Cooperative Research Centers: Generate breakthrough research by enabling close and sustained engagement among industry innovators, world-class academic teams, and government agencies. *NSF, OUSD(R&E)*
- Microelectronics Commons Advanced Component Development and Prototypes: enable the demonstration of at-scale viability of domestic microelectronics innovations. *OUSD(R&E)*
- SBIR and STTR: Transform scientific discovery into products and services with commercial potential and/or societal benefit. *NSF*

3.7.2 Key Coordination Activities

- Subcommittee on Microelectronics Leadership: Coordinate Federal activities in support of the CHIPS and Science Act of 2022 and other microelectronics R&D. *AFRL, ARL, DARPA, DHS, DOC, DOD, DOE/EERE, DOE/NNSA, DOE/SC, FBI, IARPA, NASA, NIST, NRL, NSA, NSF, ODNI, State*
- ERI: Coordinate across DOD and government on dual-use electronics development activities to include annual ERI Summit. *AFRL, ARL, ARO, DARPA, DOE/SC, NIST, NRL, NSF, ONR, OUSD(R&E)*
- Microelectronics Commons FY24 Awards to Innovation Hubs: Awards to Innovation hub performers (Universities, startups, incubators, Federally Funded Research and Development Centers (FFRDCs), Federal Labs, semiconductor companies, and Defense Industrial Base companies) participating in the Commons innovation network as centers of expertise in one or more of six DOD-critical technical areas. *Army, DAF, DOC, Navy, NSF, OUSD(R&E)*
- University-Based Cybersecurity R&D Centers: Establish a network of university-based, regional electric power cybersecurity R&D centers that address interrelated R&D challenges of cybersecurity and critical energy infrastructure, while considering the distinctive characteristics of each region’s electricity system, network of infrastructure, and workforce expertise. *DOE/CESER*

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

EHCS R&D advances and translates new approaches in high-capability computing; this includes R&D in novel computing paradigms, hardware architectures, algorithms, software, data analytics, system performance, reliability, trust, transparency, energy efficiency, and other methods that enable extreme data- and compute-intensive workloads.

3.8.1 High End Computing (HEC) IWG

Participating Agencies: *AFRL, Army, DOE/NNSA, DOE/SC, NASA, Navy, NIH, NIST, NOAA, NSA, NSF, OUSD(R&E)*

The HEC IWG coordinates Federal R&D to advance U.S. leadership in high-capability computing (HCC). From supercomputers and large-scale data centers to mobile data acquisition-and-analysis system, HCC permeates critical U.S. capabilities and technological leadership. With the slowdown of Moore’s Law, the rapidly evolving technology landscape and user needs, along with energy efficiency needs drive transformational and incremental advancements in all areas of HCC to meet capability goals and productivity requirements needed to enhance scientific insight, accelerate discoveries, and prepare for the next computing evolution.

FY24 Administration Priorities: EHCS Examples**Advancing National Security and Technological Competitiveness: Washington Metropolitan Quantum Network Research Consortium**

Create, demonstrate, and operate a quantum network as a regional testbed. Army, DOD, Navy, NASA, NIST. (<https://www.nist.gov/news-events/news/2022/06/dc-area-us-government-agencies-announce-washington-metropolitan-quantum>)

Advancing National Security and Technological Competitiveness: Project 38

Explore vendor-agnostic architectural options. DOD, DOE/NNSA, DOE/SC. (<https://crd.lbl.gov/divisions/amcr/computer-science-amcr/cag/research/project-38>)

Cultivating an Equitable STEM Education, Engagement, and Workforce Ecosystem: Computational Science Graduate Fellowship

Aims to meet the Nation's growing need for science and technology professionals with advanced computer skills. DOE/SC, DOE/NNSA. (<https://science.osti.gov/ascr/CSGF>)

3.8.1.1 Strategic Priorities and Associated Key Programs

Following are the HEC IWG's EHCS strategic priorities and relevant programs.

1. Research and develop innovative approaches and technologies critical to delivering extreme-scale computing systems to enhance scientific insight, accelerate discoveries, and reinforce decision-making in support of national priorities.

- Advanced Computing Solutions program. *DOE/NNSA, DOE/SC, NIH*
- Benchmarking and exploring emerging architecture via a testbed. *Army, Navy*
- Exascale Computing Project (ECP): Test application and software technology on early hardware and prepare for ECP transition. *DOE/NNSA, DOE/SC*
- Advanced Architecture Exploration and Prototype System Development; Post Exascale Computing Initiative component technology investigation. *DOE/NNSA*
- Application Software Modernization; Computing testbed program. *NASA*
- Computational and Data-Enabled Science and Engineering (CDS&E), as well as the Advanced Cyberinfrastructure Core Program, Computer Systems Research Core Program, Foundations of Emerging Technologies Core Program, and Software and Hardware Foundations Core Program. *NSF*
- R&D metrology and logic and memory devices; Assure supply chain of older and current generation devices. *NIST*

2. Research and develop technologies to make breakthroughs in HCC's most pressing challenges and pioneer new frontiers in computing, fueling innovations and discoveries that will shape the future computing ecosystem and strengthen technological competitiveness.

- AI-enabled high-performance simulations and computing technologies. *Army, DOE/NNSA, NASA*
- Explore high-performance architectures, including non von Neumann architectures, and adapt to DOD priority areas. *AFRL, Army*

- R&D domain-aware AI algorithms and programming tools and runtime environments that support new AI and ML workflows, Microelectronics research. *DOE/SC*
- R&D to advance neuromorphic computing. *AFOSR, AFRL, NSF*
- Explore neuromorphic computing via testbeds. *DOE/NNSA, NASA*
- Develop mixed analog-digital neuromorphic processor for power efficiencies: Explore fault tolerance and radiation tolerance for neuromorphic computing. *NASA*
- Develop superconducting and optoelectronic devices and algorithms for neuromorphic processors. *AFOSR, NIST*
- R&D for new types of bio-inspired algorithms to support the development of reconfigurable neuromorphic computing systems. *DOE/SC, NSF*
- Washington Metropolitan Quantum Network Research Consortium (DC-Qnet): Create, demonstrate, and operate a quantum network as a regional testbed. *Army, DOD, NASA, Navy, NIST*
- Quantum Artificial Intelligence Laboratory: Research and evaluate new experimental systems. *NASA, industry partners*
- Development of new algorithms, simulations, and control systems. *DOE/NNSA*
- Quantum Computing and Network Research: Continue basic research in quantum algorithms, applications, networking, and testbeds. *AFRL, DOE/SC, NSF*
- Quantum Sensing Challenges for Transformational Advances in Quantum Systems: Support interdisciplinary teams to explore quantum sensing and apply it to quantum sensor systems, with demonstrations resulting in proof of principle or field-testing of concepts and platforms. *NSF*
- Convergence Accelerator track on quantum technology. *NSF*
- Quantum networking. *AFRL, NIST*
- Improve quantum characterization. *NIST*
- Explore quantum error correction, limitation of quantum circuits, and potentials and limitations of quantum computers. *NIST*

3. Research and develop new approaches and techniques to improve the programmability, portability, reliability, and usability of high-capability computing boosting the productivity and applicability of the HCC ecosystem.

- Cloud computing and HCC assimilation. *NASA, NSF*
- Hedgehog: Research to identify software abstraction for parallelism targeting high-end heterogeneous compute nodes. *NIST*
- Cluster Scale Abstraction: Develop cluster scale asynchronous run time system. *NIST*
- Principles and Practices of Scalable Systems: Support research to increase scalability in large-scale parallel computer systems. *NSF*
- Productivity Enhancement and Training: Explore and adopt new programming approaches that take advantage of state-of-the-art hardware and software. *Army*

- Software Stack for Extreme HPC Heterogeneity: Basic R&D beyond exascale, including advanced programming models, data reduction (both in algorithms and computing technology), storage and data management, programming environments, and methodologies for highly heterogeneous systems. *DOE/SC*

4. Develop, foster, and broaden a diverse and inclusive HEC workforce for computing R&D to bolster technological competitiveness. See the EdW PCA for education, training, and career development related activities.

3.8.1.2 Key Coordination Activities

- Post ECP software sustainability, including annual ECP Principal Investigator meeting: Provide collaborative working forum and broaden user and developer community for the open-sourced applications codes and software technologies for post-ECP sustainment. *DOE/NNSA, DOE/SC, other agencies, computing technology stakeholders*
- Quantum Economic Development Consortium: Enable and grow the U.S. quantum industry by identifying gaps in technology, standards, and workforce and to address those gaps through collaboration. *NIST, other agencies, academic and technology industry partners*
- Joint Center for Quantum Information and Computer Science: Partnership to advance research and education in quantum computer science and quantum information theory. *DOD, NIST, academic partners*
- Project 38: Explore vendor-agnostic architectural options. *DOD, DOE/NNSA, DOE/SC*
- Explore the opportunity that QIS offers for biomedical research via pilots. *DOE, NIH*

3.9 High-Capability Computing Infrastructure and Applications (HCIA) PCA

HCIA provides the operation, integration, and utilization of high-capability computing systems and infrastructure supporting computation-intensive and data-intensive application workflows; this includes software and services, communications, storage, data infrastructure, coordination services, and other necessary resources for the effective use of high-capability computing.

3.9.1 High End Computing (HEC) IWG

Participating Agencies: *DOD, DOE/NNSA, DOE/SC, NASA, NIH, NCI, NIST, NOAA, NSA, NSF, USGS*

In addition to coordinating EHCS R&D, the HEC IWG coordinates Federal activities to provide HCC systems and infrastructure (including expertise necessary to use the HCC systems effectively) and develop algorithms and applications to accelerate scientific discoveries and technological innovations in areas such as materials discovery and design, energy applications, Earth and space science, early-stage research of advanced technologies, understanding of human body for detection and treatment of diseases, advanced weapons, forecasting and hazard response planning, and many other S&E applications vital to our Nation.

FY24 Administration Priorities: HCIA Examples***Reducing the Death Rate from Cancer By Half: NCI-DOE Collaboration for Advanced Computing Solutions***

Collaborative research in computational neuroscience. DOE/NNSA, DOE/SC, NIH/NCI. (<https://datascience.cancer.gov/collaborations/nci-department-energy-collaborations>)

Promoting Open Science and Community-Engaged R&D: Open-Source Science Initiative

Enable and support moving science towards openness, including policy adjustments, supporting open-source software, and enabling cyberinfrastructure. NASA. (<https://science.nasa.gov/open-science-overview>)

3.9.1.1 Strategic Priorities and Associated Key Programs

Following are the HEC IWG's HCIA strategic priorities and relevant programs.

1. Acquire, operate, and provide researchers HCC systems with the varying capabilities required to meet critical national needs and support research and education across all S&E areas.

- COVID and Translational Science supercomputer. *NIH*
- Deployment of a new computation system in collaboration with academia; Enhancement and/or replacement of Hera, a system for weather modeling. *NOAA, academic partners*
- Expansion of HCC capabilities for research via a partnership with other leading-edge centers in the U.S. and purchase of medium-scale cluster. *NIST*
- HCC of varying capabilities through Leadership-Class Computing Facility program; the Advanced Computing Systems and Services: Adapting to the Rapid Evolution of Science and Engineering Research; National Center for Atmospheric Research-Wyoming Supercomputing Center; Major Research Instrumentation. *NSF*
- High-End Computing Capability Project. *NASA*
- Leadership HCC at computing facilities in Argonne (Polaris, Aurora) and Oak Ridge (Frontier) National Laboratories; Phase 2 upgrade of Perlmutter supercomputer at National Energy Research Scientific Computing Center. *DOE/SC*
- Varying computing resources through Dedicated High Performance Computing Project Investments; Cloud HPC; Dedicated High Performance Investments. *DOD*

2. Develop, improve, and maintain algorithms, applications, and supporting software to advance capabilities vital to the Nation's security, economy, and individual well-being.

- Development and maintenance of GridTools for Python. *NASA, NOAA*
- Code modernization hackathons; Computational Modeling and Analysis program: Advance computational modeling and analysis methods for aerospace propulsion components and systems. *NASA*
- CSSI. *NSF*
- Pathways to Enable Open-Source Ecosystems. *NSF*

- Computational and Data-Enabled Science and Engineering. *NSF*
- Development of mathematical and computer models for pandemic readiness. *NIST*
- Deep learning to analyze images (e.g., microscopy, MRI) and prediction of physical and chemical properties of molecules. *NIST*
- Measurement based R&D to develop best-practice guidelines for deployment of secure, high-performance software-defined networks. *NIST, OUSD(R&E)*
- High Performance Computing Modernization Program software applications; Computational Research and Engineering Acquisition Tools and Environments Program. *DOD*
- Efforts in ECP algorithms, applications, and workflow development for next-generation platforms. *DOE/SC*
- Development and support of software sustainability and stewardship on modern computing platforms. *DOE/SC*
- Optimization of the primary forecast model for GPUs. *NOAA*
- Support development and maintenance of domain-specific language tools for forecasting. *NOAA*
- Psychiatric Cell Map Initiative. *NIH*
- National Institute of Mental Health Data Archive; Precision Nutrition. *NIH*

3. Develop resources and tools to lower barriers to HCC access, improve usability, and support collaborations to promote community-engaged R&D.

- Cloud access portal. *DOD, NOAA*
- Web-based HPC application interfaces. *DOD, NASA*
- ECP software development kits and software stacks; Extensive training programs at Argonne Leadership Computing Facility, Oak Ridge Leadership Computing Facility, and Northeast Solar Energy Research Center on new AI/ML technologies and for new exascale systems. *DOE/SC*
- IDeA Networks of Biomedical Research Excellence; Common Fund Data Ecosystem; ASPIRE Integrated Computational Platform for support of automated, high throughput synthesis of new opioid of drugs to help combat drug addiction. *NIH*
- Immersive Scientific Visualization: Development of low-cost hardware to enable the use of consumer VR tracking to produce a cave-like experience in an office environment. *NIST*
- Partnership to Advance Throughput Computing; Campus Cyberinfrastructure Program. *NSF*
- Support of open-source code development and GitHub to enhance collaboration and community development; Utilization of infrastructure as code and open-source applications and datasets to facilitate open science. *NASA*

4. Develop, enhance, and provide an HCC ecosystem to a diverse user community, including facilities and resources, needed for effective use of advanced computing to support U.S. leadership in S&E, enable open science and community-engaged R&D, and strengthen U.S. competitiveness.

- Advanced Cyberinfrastructure Coordination Ecosystem: Services and Support program. *NSF*
- Augment user support with the addition of software engineers. *NIST*

- Clinical Center Computational Facilities and Infrastructure; Cloud Platform Interoperability Initiative; Clinical Trial Infrastructure. *NIH*
- DOD ecosystem. *DOD*
- Expansion of the HCC infrastructure to create a climate and earth science framework. *USGS*
- NASA Computing Services project. *NASA*
- Operations and upgrades at the leadership computing facilities, including ESnet. *DOE/SC*

3.9.1.2 Key Coordination Activities

- Collaborative research in computational neuroscience. *DOE/NNSA, DOE/SC, NCI*
- Establishment of the Computational Center for Earth Sciences for climate research. *NSF, USGS*

3.10 Intelligent Robotics and Autonomous Systems (IRAS) PCA

IRAS R&D advances intelligent robotic systems that are increasingly autonomous; this includes R&D in robotics hardware and software design and application, machine perception, cognition and adaptation, mobility and manipulation, safe human-robot interaction, and distributed and networked robotics.

3.10.1 Intelligent Robotics and Autonomous Systems IWG

Participating Agencies: *AFOSR, ARL, Army, DAF, DHS, DOD, DOL, DOT, FAA, GVSC, Marine Corps, MDA, NASA, Navy, NIDILRR, NIFA, NIH, NIOSH, NIST, NRC, NSF, ONR, OUSD(R&E), OSHA, TRMC, USSF*

The IRAS IWG coordinates Federal R&D in accelerating the development and use of IRAS in workplaces, hospitals, communities, and homes. IRAS targets R&D for robust, safe, ethical, resilient, and efficient robots and robotics systems that assist people in their work and everyday lives.

FY24 Administration Priorities: IRAS Examples

Reducing the Death Rate from Cancer by Half: Smart Health and Biomedical Research in the Era of Artificial Intelligence and Advanced Data Science

Develop 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. *NIH, NSF.* (<https://datascience.nih.gov/sch>)

Tackling Climate Change: Navigating the New Arctic

Cultivate innovations in fundamental convergence research across the social, natural, environmental, computing and information sciences, and engineering that address the interactions or connections among natural and built environments and social systems, and how these connections inform our understanding of Arctic change and its local and global effects. *NSF.* (<https://www.nsf.gov/geo/opp/arctic/naa/index.jsp>)

Innovating for Equity: Expanding AI Innovation through Capacity Building and Partnerships

Aims to significantly broaden participation in AI research, education, and workforce development through capacity development projects and through partnerships within the National AI Research Institutes ecosystem. *NSF.* (<https://new.nsf.gov/funding/opportunities/expanding-ai-innovation-through-capacity-building>)

3.10.1.1 Strategic Priorities and Associated Key Programs

Following are the IRAS IWG's strategic priorities and relevant programs.

1. Advance safe, efficient human-robot teaming and interactions to increase performance and enable new capabilities.

- Assured DevSecOps of Autonomous Systems portfolio pathfinder. *DAF, Marine Corps, Navy*
- Autonomy and Artificial Intelligence Testing: Invest in test and evaluation technologies, capabilities, and infrastructure to address current needs of test and evaluation community and future needs aligned to DOD's modernization goals, including autonomy and AI. *AFOSR, DARPA, Navy, TRMC*
- Next Generation Combat Vehicle Robotics: Improve human-autonomy teaming and enable scalable multi-domain autonomy while lowering cognitive load for operators and optimizing effectiveness. *AFOSR, ARL, Army-GVSC*
- Human-Centered Computing: Support research in human-computer interaction, including human-robot interactions. *AFOSR, NSF*
- Human-Machine Teaming project: Focus design decisions on explicit allocation of cognitive functions and responsibilities between human and computer to achieve specific capabilities. *AFOSR, MDA*
- Performance of Human-Robot Interaction: Provide methods, protocols, and metrics to evaluate interactive and teaming capabilities of human-robot systems. *AFOSR, NIST*
- Advance human-robot teaming for space exploration: Develop methods to produce efficient user interfaces and techniques to facilitate understanding of robot autonomy. *NASA*
- Aeronautics University Leadership Initiative: Effective Human-Robot Teaming to Advance Aviation Manufacturing: Research on how human-robot teaming can improve the efficiency of aviation manufacturing, while enhancing ergonomics and safety. *NASA*
- Intervention research to improve safety around robots: Development and evaluation of engineering controls and workplace interventions for safe and effective human-robot teaming. *NIOSH*
- Mind, Machine, and Motor Nexus: Support fundamental research and integrated design of physical interactions between humans and intelligent machines. *NSF*
- Research evaluating risk factors with robot-related injuries: Study of contributing factors, including task and environmental characteristics as well as biomechanics, anthropometry, and cognition. *NIOSH*
- Research human-robot collaboration: Development and evaluation of engineering controls and workplace interventions for safe and effective human-robot teaming. *NIOSH*
- Trust and Reliance of Humans on Robots: Provide metrics to evaluate trust between human and robot interaction. *AFOSR*

2. Improve robots and autonomous systems to robustly sense, model, plan, learn, and act appropriately to perform the required tasks including in complex and uncertain situations.

- Autonomy and AI Modeling and Simulation: R&D for modeling and simulation services to enable autonomous and AI code in digital twin test environments to evaluate the behavior and capabilities of AI and autonomous systems before they are deployed in operational test environments. *Navy, OUSD(R&E) CTO, TRMC*
- Automated Machine Learning for Mine Countermeasure Operations: Establish Machine Learning Operations pipelines to support continuous deployment, monitoring, and updating of existing models using mine countermeasure use-case. *DIU, Navy, TRMC*
- Operational trust in mission autonomy: Establish trust in AI-enabled systems, and methods to measure and assess it in human-agent collaboration. *AFOSR, OUSD(R&E), TRMC*
- CPS for agriculture: Advance S&T applied to S&CC (both rural and urban); Real-time agricultural data analytics and control. *NIFA, NSF*
- Dynamics, Control and Systems Diagnostics: Support fundamental research on analysis, measurement, monitoring, and control of dynamic systems. *AFOSR, NSF*
- Foundational Research in Robotics: Support research on robotic systems that exhibit significant levels of both computational capability and physical complexity. *NSF, USDA*
- Game changing development: Develop autonomy technologies for future space missions including multi-robot teaming. *AFOSR, NASA*
- Robust Intelligence: Develop systems that can sense, learn, reason, communicate, and act in the world. *AFOSR, NSF*
- Soldier Situational Awareness: Develop algorithms for dismounted robotic systems to enable autonomous navigation, automated object recognition, persistent surveillance, launch and recovery from vehicles, networked lethality, manned-unmanned teaming, and collaborative behaviors; and advanced user interfaces to optimize human-robotic interaction during dismounted operations. *AFOSR, ARL*
- Advanced Teaming for Tactical Operations: Develop and demonstrate integrated solutions for advanced teaming of multiple manned and intelligent unmanned aviation assets to execute tactical missions with minimal human intervention. *Army*
- Fundamental Research for Robust and Safe Perception-in-the-loop Control: Develop methods and metrics for control of autonomous systems with machine perception in a feedback loop that are robust to uncertainty and perturbations and can be formally verified. *AFOSR*
- Embodied AI and Data Generation for Manned-Unmanned Teaming: Provide structured AI/ML training datasets and proven, trained, and applied AI/ML models to improve performance and autonomy of manufacturing robotic applications. *NIST*
- Engineering for Precision Crop and Water Management: Develop engineered devices, technologies, sensors, and tools to provide precision crop and orchard management, and technologies for targeted application of crop protection materials; and improve efficiency of irrigation and nutrient use in agricultural systems. *NIFA*

- Grasping, Manipulation, and Safety Performance of Robotics Systems: Develop measurement science to assure and advance the safety and performance of industrial arms and grasping mechanisms. *NIST*
- NASA Innovative Advanced Concepts: Develop new types of space robots to explore extreme environments. *NASA*
- Perception Performance of Robotics Systems: Develop measurement science for sensing and perception system performance characterization to reduce risk related to adoption of new technologies and to advance agility, safety, and productivity of collaborative industrial and mobile robots. *NIST*
- Prognostics and Health Management: Develop and deploy measurement science to promote the implementation, verification, and validation of advanced monitoring, diagnostic, and prognostic technologies to increase reliability and decrease downtime in smart manufacturing robotic systems. *NIST*
- Safety standards, certifications, and regulations: Evaluation of effectiveness of existing safety standards, certifications, and regulations for the development of new consensus standards. *NIOSH*
- Robot-related workplace fatalities and injury surveillance: Improve surveillance tools to effectively capture robot-related workplace injuries. *NIOSH*
- Space Technology Research Grants: Coordinated multi-robot coordination for planetary exploration. *NASA*

3. Advance a new generation of robots, such as nanorobots, wearable robots, soft robots, and biologically inspired robots.

- Brain-Inspired Dynamics for Engineering Energy-Efficient Circuits and AI: Create new engineering science of brain-inspired engineered learning systems. *AFOSR, NSF*
- Smart Health and Biomedical Research in the Era of AI and Advanced Data Science: Support development of transformative high-risk, high-reward advances in computer and information science, engineering, mathematics, statistics, and behavioral and/or cognitive research to address pressing questions in biomedical and public health communities. *NIH, NSF*
- Disability and Rehabilitation Engineering: Support fundamental engineering research that will improve quality of life of persons with disabilities through development of new technologies, devices, or software combined with advancement of knowledge regarding healthy or pathological human motion, or advancement in understanding of injury mechanisms. *NSF*
- Disability and Rehabilitation Engineering: Support basic and applied engineering R&D of intelligent robotics and autonomous systems that enable people with disabilities and older adults to live more independently. *NIDILRR*
- Measurement science, standards, and test methods for soft robotics. *NIST*
- National AI Research Institute: Address challenges in methods, data, privacy, and fairness that advance foundational AI R&D and agriculture and food systems. *NIFA*
- Performance Evaluation of Exoskeleton Technology. *NIST*

- Physical Augmentation: Research the science of movement for physical augmentation to maximize mobility capacity and training adaptation to decrease learning curve with physical augmentation systems (e.g., physical-assist devices). *ARL*
- Research on safety benefits, and risks with powered exoskeletons. *NIOSH*
- NASA Space Technology Graduate Research Opportunity awards: Develop such technology as: (1) a robotic gripper powered by self-sensing twisted string actuators, (2) a multi-legged free-climbing robot with micro-spine grippers, (3) a steerable, burrowing robot that extends from its tip and uses gas to fluidize surrounding soil, and (4) an end-effector for anchoring to frangible substrates based on jamming interaction. *NASA*

4. Advance the role of robotics in improving the resilience of critical infrastructure: (a) to respond to failures or incomplete or corrupted information; and (b) to assist in national response to critical and unexpected events including national disasters and emergencies.

- Agility Performance of Robotic Systems: Deliver robot agility performance metrics, test methods, information models, datasets, and planning approaches that enable manufacturers to more easily and rapidly reconfigure and re-task robotic systems. *NIST*
- America's Seed Fund (SBIR and STTR): Foster innovation in robotic applications in healthcare and next-generation automation. *NSF*
- Applied Information Systems Research: Apply innovative ideas for advanced information and related technologies to increase life cycle effectiveness and efficiency of Science Mission Directorate programs. *NASA*
- Autonomous Systems Test Capability: Provide a three-phased approach to safely test autonomous ground vehicles: lab-based simulations, hardware in the loop, and live testing with safety monitoring. *Army, Navy*
- Concepts for Ocean Worlds Life Detection Technology: Support development of spacecraft-based technology for surface and subsurface exploration of ocean worlds. *NASA*
- Partnerships for Innovation: Perform translational research and technology development, catalyze partnerships, and accelerate transition of discoveries from laboratory to marketplace for societal benefit. *NSF*
- Research on adaptable robots for use in dynamic situations. *NIOSH*
- Plant Production and Protection (SBIR Engineering): Enhance crop production in both conventional and organic systems by creating and commercializing engineering technologies that enhance system efficiency and profitability and that protect crops from pests and pathogens in economically and environmentally sound ways. *NIFA*
- Smart deep space habitat. *NASA*

5. Promote ethical standards and broader participation in robotics.

- Space Technology announcement of collaboration opportunity. *NASA, SBIR and STTR partners*
- AFRI Education and Community Development Programs: Professional development, education, and workforce development, including development of a technology- and data-savvy workforce ready for field and industrial jobs in food and agricultural sciences. *NIFA*
- Broadening Participation in Computing. *NSF*

- Evaluation of training on the effects of new technologies on health equity, worker displacement, and robotics education. *NIOSH*
- NASA Space Technology Graduate Research Opportunity. *NASA*
- NSF Research Traineeship Program: Develop ways for research-based graduate students to develop skills, knowledge, and competencies needed to pursue STEM careers. *NSF*
- Tools for Collaborative Robots Within SME Workcells: Deliver suite of tools that facilitate calibration procedures for individual robots, robot-to-robot coordination, sensors, and grippers to mitigate lack of automation and technical expertise that currently prevents small and medium manufacturers from adopting robotic systems. *NIST*

3.10.1.2 Key Coordination Activities

- Principal Investigator meetings: Review research, identify new applications, and discuss S&T gaps and barriers. *AFOSR, DHS, DOT, NASA, Navy, NIFA, NIH, NIOSH, NIST, NSA, NSF, ONR*
- Safety and other standards development: ASTM Committees E54 on Homeland Security Applications and F48 on Exoskeletons and Exosuits; Manufacturing robot and other safety standards: Develop and set terminology, safety, and performance standards for robots, industrial vehicles, exoskeletons, mobile manipulators, etc. *DHS, DOD, DOE, DOJ, FAA, NIH, NIOSH, NIST, NRC*
- Metrics, Evaluation, and Software Infrastructure: Develop open-source metrics, performance test methods, and interoperability. *Army, DAF, Navy, NIST, industry partners*
- Advanced Robotics for Manufacturing Institute: Develop open-source, interoperable performance metrics and test methods. *DOD, NIOSH, NIST, academic and industry partners*
- Robot Safety Standards: Revisions of ISO TC299 and ANSI/RIA R15.06 to include standards for collaborative robotic applications; Development of mobile robot safety standard (ANSI/RIA R15.08). *NIH, NIOSH, NIST, OSHA, academic and industry partners*
- Association for Advancing Automation Alliance Agreement: Increase workplace safety related to intelligent and autonomous systems, share technical knowledge and best practices, improve hazard awareness, and identify research on collaborative robot technologies and systems. *NIOSH, OSHA, industry partners*
- Drone safety standards: Participate in the ANSI Unmanned Aircraft Systems Standardization Collaborative and add worker safety considerations to ANSI Roadmap. *NIOSH, NIST, academic and industry partners*
- IEEE P3107 Standard Terminology for Human-Robot Interaction: Define terms relevant to human-robot interaction in service, social, education, industrial, and research robotic applications. *ARL, NASA, NIST, academic and industry partners*
- IEEE Study Group on Metrology for Human-Robot Interaction: Identify key performance indicators of human-robot interaction (HRI) effectiveness and develop metrics and test methods by which HRI performance may be assessed. *NASA, NIST, academic and industry partners*
- IEEE 1872.2 Autonomous Robotics Ontology Working Group: Represent more specific concepts and axioms that are commonly used in autonomous robotics. *NASA, NIST, academic and industry partners*

- Space Trusted Autonomy: Identify and prioritize development of self-sustaining and reliable technologies that are certified for mission use. *NASA, NRO, USSF*
- IEEE Future Directions Project, Telepresence: Technology roadmap and standards to facilitate the use and benefits of telepresence. *NASA, JPL*
- Mine Automation and Emerging Technologies Health and Safety Partnership: Hold annual partnership meetings with key mining stakeholders interested in automation, robotics, and other emerging technologies. *NIOSH, industry partners*
- Multidisciplinary University Research Initiative: Support research teams for which research efforts intersect more than one traditional S&E discipline. *DOD, academic partners*
- NASA Jet Propulsion Laboratory: Advance robotics technologies for search and rescue in underground environments. *NASA, NIOSH*
- IEEE P1872.1 Robot Task Representation Working Group: Represent, reason about, and communicate task knowledge in robotics and automation domain. *NIST*
- IEEE P2940 Standard for Measuring Robot Agility: Represent desirable traits of robotic systems under umbrella of agility, compound notion of reconfigurability and autonomy as opposed to typical robotic use of rigid pre-programmed tasks. *NIST*
- International Collaborations
 - Technology Cooperation Sub-Committee Autonomy and AI Working Group: Work bilaterally with Republic of (South) Korea on cyber and drone defense, autonomous situation awareness, scalable teaming, unmanned ground robots. *DOD Service Labs, OUSD(R&E), Republic of (South) Korea Agency for Defense Development*
 - U.S. and UK Autonomy and AI Working Group: Engage in bilateral efforts on autonomy and AI-enabled brigade support, collaboration infrastructure and enablers, joint autonomy and AI toolbox, and research in autonomous and AI-based systems. *DOD Service Labs, OUSD(R&E), UK-Dstl*
 - Australia, UK, U.S. partnership: Accelerating adoption, and improving the resilience of, autonomous and AI-enabled systems in contested environments. *Army, Air Force, Navy, OUSD(R&E), UK-Dstl, Australian Defence Science and Technology Organization*

3.11 Large-Scale Data Management and Analysis (LSDMA) PCA

LSDMA R&D advances the ecosystem needed for extraction of knowledge and insights from data; this includes R&D in the capture, curation, provenance, privacy preservation, management, governance, access, analysis, reusability, and presentation of large-scale and diverse data.

3.11.1 Big Data (BD) IWG

Participating Agencies: DARPA, DHS, DOE/SC, NIH, NIST, NSF, USDA

The BD IWG coordinates Federal R&D to enable effective analysis, decision-making, and discovery based on large, diverse, real-time data. LSDMA R&D expands big data and data science capabilities, providing the foundation for algorithm-driven businesses and catalyzing innovations critical to the Nation.

FY24 Administration Priorities: LSDMA Examples***Promoting Open Science and Community-Engaged R&D: NIH Cloud Platform Interoperability***

Create a federated data ecosystem and is a critical step toward improving researchers' access to all types of data. NIH. (<https://datascience.nih.gov/nih-cloud-platform-interoperability-effort>)

Promoting Open Science and Community-Engaged R&D: Geosciences Open Science Ecosystem

Support an ecosystem of sustainable and networked open science activities and capabilities that foster inclusive access to data, physical collections, software, advanced computing, and other resources toward advancing research and education in the geosciences. NSF. (<https://new.nsf.gov/funding/opportunities/geosciences-open-science-ecosystem-geo-ose>)

Advancing National Security and Technological Competitiveness: Transdisciplinary Research in Principles of Data Science

Fundamental research and training in theoretical foundations of data science. NSF. (<https://nsf-tripods.org>)

3.11.1.1 Strategic Priorities and Associated Key Programs

Following are the BD IWG's strategic priorities and relevant programs.

1. Support the foundational research of innovative tools and methodologies to solve problems of national and societal importance and maximize the use of large-scale data resources.

- Adolescent Brain Cognitive Development Consortium Informatics and Resource Center: Research data analytics and informatics. *NIH*
- CDS&E program: Computational and data-analysis approaches and best practices. *NSF*
- CISE core program: Innovative research on data science techniques. *NSF*
- Foundational research in storage systems and input and output, data visualization, and bio-preparedness research virtual environment. *DOE/SC*
- National Center for Digital Health Informatics Innovation: A national network enabling digital health research. *NIH*
- Precision Nutrition: Integrate precision nutrition, AI, systems biology, systems science, big data, and computational analytics. *NIH*
- Principles and Practices of Scalable Systems: Basic research on scalability of modern systems, applications, and toolchains and fostering the development of principles leading to reproducible artifacts. *NSF*
- Resilient Supply-and-Demand Networks: Develop analytical techniques and tools for stress-testing supply-and-demand networks. *DARPA*
- Semantics Forensics: Develop algorithms and semantic technologies to analyze and assess the integrity of media. *DARPA*
- Synthetic Data for creating synthetic datasets. *DHS*
- Multi-Cloud Ecosystem: Access to multiple clouds to train models and develop analytics on sensitive cybersecurity data. *DHS*

- Transdisciplinary Research in Principles of Data Science: Fundamental research and training in theoretical foundations of data science. *NSF*

2. Advance the reliability, accuracy, performance, generalizability, transparency, and security of data-driven discovery and decision making to better support innovation in S&T, enhance national security, and technological competitiveness.

- National AI Research Institutes (data aspects): Accelerate the transition of AI innovations into many economic sectors. *DOD, NIST, NSF, USDA*
- Data quality standards development for analytics and ML. *NIST*
- End-to-End Clinical Decision Support Tools for predicting the risk of drug-induced lethal arrhythmia based on deep learning, assisting clinicians in selecting treatments that balance survival and side-effects response to cancer therapy, and identification, diagnosis, and treatment of hospitalized patients at high risk of clinical deterioration. *NIH*
- Foundational research in uncertainty quantification focused on understanding the uncertainty arising from complex or sparse data and the effects on decision-making. *DOE/SC*
- Fundamental research into explainable and scalable AI and into scientific ML for complex systems. *DOE/SC*
- Research for model drift and bias detection. *DHS*
- Secure and Trustworthy Cyberspace Program: Research on the topics of data science, ML, and AI in service of data security and privacy. *NSF*
- Cybersecurity Innovation for Cyberinfrastructure: Applied security and privacy research. *NSF*

3. Facilitate the sharing, discoverability, interoperability, and reusability of diverse data that are scalable and agile enough to meet the needs of innovation and support open science and community-engaged R&D.

- Big Data Governance and Metadata Management Framework: Develop a standard Big Data Governance and Metadata Framework that is scalable and can enable the FAIR between heterogeneous datasets from various domains. *NIST, academic and industry partners*
- Advanced Cyberinfrastructure Coordination Ecosystem: Provide NSF-supported advanced shared resources. *NSF*
- Public Access Repositories 3.0: Achieve faster delivery time and expanded types of research products disseminated for public access. *NSF*
- FAIR Open Science Research Coordination Networks: Support coordination among researchers and other stakeholders to advance FAIR data principles and open science practices. *NSF*
- Convergence Accelerator: Enable use-inspired, convergence research in areas of national importance via partnerships between academic and non-academic stakeholders. *NSF*
- CSSI: Support interoperability of data and provide an opportunity to advance common approaches to sustain and innovate research cyberinfrastructure. *NSF*
- Campus Cyberinfrastructure: Address science-driven needs in data storage resources and shared resources at the regional level. *NSF*

- GEO Open Science Ecosystem to advance open science principles in the geosciences. *NSF*
- Auto-ML for the development of tools to automate the creation of labelled datasets. *DHS*
- Interoperability Data Infrastructure for Research on the Aging Life Course: Enable a cross-domain integration framework that will maintain the interoperable data collections, integrate the support services, bibliographic tracking, and social media outreach to support aging research. *NIH*
- Cloud Platform Interoperability Initiative: Create a federated data ecosystem. *NIH*
- Research FAIR data and models for science to advance the state of the art in AI/ML. *DOE/SC*

4. Enable time-sensitive data-driven decision making through scalable high-performance analytics ecosystems.

- Codesign and data analysis and reuse at scientific user facilities. *DOE/SC*
- Development of integrated research infrastructure. *DOE/SC*
- Distributed sensing and model-driven prediction for firefighters in which many diverse sensors combine to provide cohesive situational awareness. *DHS*
- Exploration of approaches to create distributed, resilient systems for science. *DOE/SC*
- Explore making analytics as services for developing real-time machine-actionable and composable analytics as scalable and federated services to support reusable, deployable, and operational for big data, HPC, and AI/ML and DL deep learning applications. *NIST*
- Foundational research in data reduction. *DOE/SC*
- Lifetime Imaging and Real-Time Data Systems for Surgical and Medical Guidance for fast and flexible data acquisition and display and real-time data infrastructure. *NIH*
- National AI Research Institutes (time-sensitive data-driven components). *NSF*
- RECOVER: Support digital health platform for collecting real-world data in real-time. *NIH*

5. Build a diverse multigeneration workforce necessary to develop, support, and use all aspects of big data. See the EdW PCA for education, training, and career development related activities.

6. Transition research to practice by translating R&D into operational tools and technologies that enhance U.S. security, the economy, and well-being, including health and climate change.

- Accelerate Innovations in Emerging Technologies. *DOE/SC*
- Convergence Accelerator for a convergence-based approach for transitioning basic research and discovery into practice. *NSF*
- International standards. *DOE/SC*
- Pathways to Enable Open-Source Ecosystem: Harness the power of open-source development for creating new technology solutions. *NSF*
- SBIR: Complex Data. *DOE/SC*
- Scientific Discovery Through Advanced Computing partnerships. *DOE/SC*
- Software sustainability. *DOE/SC*

- Training modules focused on FAIR to educate researchers at all career levels about these issues in the research data lifecycle. *NIH*
- Transition to Practice components in various programs such as CSSI, Human Network and Data Science, Smart Health and Biomedical Research in the Era of Artificial Intelligence and Advanced Data Science, and Smart and Connected Communities (S&CC). *NSF*

7. Advance the trustworthiness, privacy, and ethics and research integrity of data to mitigate risks and bias and increase equity.

- Foundational research in federated learning. *DOE/SC*
- New policies on scientific integrity and international research integrity for NSF proposal and awards. *NSF*
- Cybersecurity Innovation for Cyberinfrastructure program, including security, integrity, provenance, and availability of end-to-end scientific workflows and data. *NSF*
- Dear Colleague Letter on reproducibility and replicability: identify policies and encourage investments to make reproducible and replicable science easier for scientific communities. *NSF*
- Privacy Enhancing Technologies: Evaluate and study their potential for implementation. *DHS*
- Supplements for advancing the ethical development and use of AI/ML in biomedical and behavioral sciences, including collection and generation of data and the reuse of data and models by others. *NIH*

3.11.1.2 Key Coordination Activities

- Subcommittee on Open Science: Participate in interagency coordination of policy around data management and open science. *BD IWG agencies, other agencies*
- Expanding AI Innovation through Capacity Building and Partnerships: Grow a broad and diverse interdisciplinary research community to advance AI-powered innovation. *DHS, DOD, NIST, NSF, USDA*

3.12 Software Productivity, Sustainability, and Quality (SPSQ) PCA

SPSQ R&D advances timely and affordable development and sustainability of low-defect, low-vulnerability software; this includes R&D to improve software development productivity, quality, measurement, assurance, and adaptability while also providing essential characteristics such as security, privacy, usability, and reliability.

3.12.1 Software Productivity, Sustainability, and Quality IWG

Participating Agencies: AFRL, Census, CDC, CISA, DARPA, DHS, DOD, FBI, IARPA, NASA, NIH, NIJ, NIST, NRC, NSA, NSF, ONC, ONR

The SPSQ IWG coordinates Federal R&D to achieve orders-of-magnitude reduction in software defects and the time and cost of developing and sustaining software. The U.S. Government and the national economy depend on increasingly complex software; improved software development technology is essential to U.S. innovation, to leadership in emerging technologies, and to security and prosperity.

3.12.1.1 Strategic Priorities and Associated Key Programs

Following are the SPSQ IWG's strategic priorities and relevant programs.

1. Advance timely, affordable development and sustainment of low-defect, low-vulnerability software through transformative research in design, production and evolution, verification, operation, utilization, and evaluation of computer software.

- Software Assurance Metrics and Tool Evaluation: Develop metrics for the effectiveness of software security assessment tools and assess current methods and tools to identify deficiencies which can lead to software product failures and vulnerabilities. *Census, DARPA, IARPA, NIST, NSA*
- Software and Hardware Foundations: Support potentially transformative research in the design, verification, operation, utilization, and evaluation of computer software and hardware through novel approaches, robust theories, high-leverage tools, and lasting principles. *DOD, NASA, NSF*
- Bugs Framework: Provide a structured, complete, orthogonal, and language-independent classification of software weaknesses. *CISA, NIST*
- Combinatorial testing: Explore methods for more effective and less expensive software testing. *NASA, NIST*
- Roots of Trust: Provide highly reliable hardware, firmware, and software components that perform specific, critical security functions. *DOD, NIST*
- Automated Vulnerability Identification Prioritization for Embedded Resources: Semi-automated software assurance toolchain that will identify vulnerabilities in software, both source and executable. *AFRL*
- Research to enable software to be built with privacy guarantees for use in biomedical and behavioral research. *NIH*
- Evaluation for common cause failure of a nuclear reactor safety function: Support regulatory approach to admit systems without diverse design redundancy. *NRC*
- Secure and Reliant CPS: Support research programs to analyze, design, re-design, update or maintain these systems. *ONR*

2. Advance software productivity, sustainability, and quality in high-priority areas such as AI, computational science and engineering, cybersecurity, and future software-defined networking.

- Computer Forensics Tool Testing: Specifications, test methods, and test data to support understanding of the functionality and limitations of software used to process digital evidence. *DHS, DOD, FBI, NIJ, NIST*
- Performance of Scalable Systems: Research to identify Software Abstractions for Parallelism targeting high-end heterogeneous compute nodes at scale. *DOD, NIH, NIST*
- Applied category theory: Lay foundations for systems integration and interoperability. *NASA, NIST*
- Trojans in Artificial Intelligence: Combat Trojan attacks by inspecting AIs for Trojans. *IARPA, NIST*

- Web Image Processing Pipelines: Ease the process for users and algorithm developers to execute and share image analyses over terabyte-sized image collections in high-throughput and high content microscopy imaging applications. *NIH, NIST*
- Autonomy: Support research on autonomous systems, which will enable us to effectively operate while protecting our personnel. *ONR*
- Cyber-Warriors: The Human Side of Cybersecurity. *ONR*
- Improve cardiovascular image-based phenotyping using emerging methods in artificial intelligence: Develop and optimize novel deep learning assisted approaches to improve diagnosis and clinical decision-making for congenital heart disease. *NIH*
- Predicting Viral-Associated Inflammatory Disease Severity in Children with Laboratory Diagnostics and Artificial Intelligence: Support research to develop novel approaches to identify and characterize the spectrum of SARS CoV-2 associated illness, including multisystem inflammatory syndrome in children and, through a prognostic algorithm, predict the longitudinal risk of disease severity after a child is exposed. *NIH*
- Secure and Trustworthy Cyberspace: Protect and preserve the growing social and economic benefits of cyber systems while ensuring security and privacy. *NSF*
- Software and Hardware Foundations Program: Research use of ML to improve software testing and analysis and other software development activities and tools. *NSF*
- Software security engineering: Research methods and tools for detecting and mitigating software vulnerabilities and malware through software analysis and testing; methods and tools for fostering security and privacy by design during software development; and improvements to security and privacy in ubiquitous computing environments (e.g., mobile, web, IoT). *NSF*
- Software Supply-chain Security: Support research on how to control and analyze the software supply chain, removing undesired code and reducing vulnerabilities. *ONR*
- Test Coverage Estimation for Max Operational Capability in Autonomous Systems: Calculus and Metrics for Quantifying Coverage of Autonomous Systems. Model-based Measurement of Test Coverage Quantification. *AFRL*

3. Develop the current and future SPSQ workforce by supporting STEM education and training; by supplying and sustaining the necessary resources such as software libraries, tools, and platforms to support teaching and research; and by advancing software proficiency and development capabilities in government organizations and government-led projects. See the EdW PCA for education, training, and career development related activities.

3.12.1.2 Key Coordination Activities

- Safety assurance of a critical safety system; evaluation for common cause failure. *AFRL, DARPA, NASA, NIST, NRL*
- Health IT testing: Develop the core health IT testing infrastructure to provide a scalable, multi-partner, automated, remote capability for current and future testing needs. *CDC, NIST, ONC*
- International Collaborations
 - Bugs Framework: Developing Bugs Framework descriptions for known exploited vulnerabilities. *CISA, Brazil*

4.0 Other NITRD Interagency Coordination Activities

4.1 Digital Health R&D (DHRD) IWG²³

Participating agencies: *AHRQ, CDC, CMS, DOE, FDA, HRSA, NIH, NIST, NSF, ONC, VA*

The DHRD IWG coordinates R&D aimed at improving the health of Americans by advancing technologies that support personalized health screening, monitoring, diagnosis, and treatment; disease prevention; emergency response; broad access to healthcare information and resources; and the building and sustainment of a diverse and highly skilled health IT workforce.

FY24 Administration Priorities: DHRD Examples

Reducing the Death Rate from Cancer By Half: Bridge to Artificial Intelligence

Promote use of artificial intelligence to address complex problems in biomedical research. DARPA, DOE, FDA, IARPA, NIH, NIST, NSF.

(<https://commonfund.nih.gov/bridge2ai>)

Reducing the Death Rate from Cancer By Half: Implementation of an Electronic Care Plan for People with Multiple Chronic Conditions

Improve care management and care coordination for people with multiple chronic conditions across different healthcare settings. ACL, AHRQ, CMS, HRSA, IHS, NIH, ONC, SAMHSA, VA. (<https://cmext.ahrq.gov/confluence/display/EC>)

Tackling Climate Change: Expanding Climate Change and Health Data Infrastructure to Advance Health Interventions

Linking Health and Environmental Data to Improve Patient and Community Health. AHRQ.

Innovating for Equity: Leading Edge Acceleration Projects in Health Information Technology

Address well-documented and fast emerging challenges that inhibit the development, use, and/or advancement of well-designed, interoperable health IT. HHS/ONC.

(<https://www.healthit.gov/topic/onc-funding-opportunities/leading-edge-acceleration-projects-leap-health-information>)

4.1.1 Strategic Priorities and Associated Key Programs

Following are the DHRD IWG's strategic priorities and relevant key programs.

1. Accelerate the R&D and Implementation of next-generation accessible, interoperable, reconfigurable digital health tools, devices, and services to enhance self-monitoring, diagnosis, treatment, and disease prevention; enable faster patient access to novel technology; provide effective point-of-care services; and reduce health disparities and inequities.

- CDSiC: Improve healthcare delivery by enhancing medical decisions with targeted clinical knowledge, patient information, and other health information. *AHRQ, CDC, CMS, FDA, NIH, ONC, VA*
- CPS: *DOT, NIH, NSF, USDA*

²³ Distinct from other IWGs, DHRD IWG and IIRD IWG agencies report funding to various PCAs, including AI, CHuman, CNPS, CPS, EdW, and IRAS, depending on the focus areas of the specific agency.

- Biomedical Research in the Era of Artificial Intelligence and Advanced Data Science: Support interdisciplinary fundamental science research to address issues in health, including improving patient access, reducing health disparities, and enhancing the usability of health tools and information. *NIH, NSF*
- Aligning Housing and Healthcare: AllianceChicago, with the Aligning Housing and Healthcare project, will partner with a Community Health Center and a community-based Homeless Service organization, among others, to prototype a shared interoperable care plan. This project will leverage Fast Health Interoperability Resources (FHIR) and the experience and capabilities of their partners to enable service providers to break down barriers to integration and coordination of services to better address social determinants of health for individuals experiencing homelessness. *ONC*
- Digital Technology for Early Detection and Monitoring of Alzheimer’s Disease and Related Dementias. *NIH*
- Disability and Rehabilitation Engineering. *NSF*
- Internet of Things in Healthcare. *NIST*
- NextGen magnetic resonance imaging. *NIST*
- Imaging for NextG instruments and therapies. *NIST*
- Validation of Digital Health and AI Tools for Improved Assessment in Epidemiological, Clinical, and Intervention Research Notice of Special Interest. *NIH*

2. Promote findable, accessible, interoperable, reusable health and biomedical data with appropriate metadata to develop new healthcare-related insights supported by advanced technologies such as AI.

- Implementation of an Electronic Care Plan for People with Multiple Chronic Conditions: Improve care management and care coordination for people with multiple chronic conditions across different healthcare settings. *ACL, AHRQ, CMS, HRSA, IHS, NIH, ONC, SAMHSA, VA*
- Bridge to AI (Bridge2AI) Initiative. *DARPA, DOE, FDA, IARPA, NIH, NIST, NSF*
- Data at Rest Quality Management Tool. *CDC, NIH, NIST*
- Accelerating Behavioral and Social Science through Ontology Development and Use. *NIH*
- Center for Evidence and Practice Improvement Evidence Discovery and Retrieval Project. *AHRQ*
- End-to-End Research Platform: Provide low latency and high-speed data rates to improve real-time training of healthcare staff, remote diagnostics, and remote surgery. *NIST*
- Equity Engines. *ONC*
- Equity through Artificial Intelligence. *ONC*
- Expanding AI Innovation through Capacity Building and Partnerships. *NSF*
- FHIR Toolkit: Supports testing of the Integrating the Healthcare Enterprise Mobile Access to Health Documents, a FHIR-based implementation guide, which provides a framework and a simulated environment to allow users to create conformance and interoperability test collections, based on a FHIR TestScript resource. *NIST*
- FAIR Open Science Research Coordination Networks. *NSF*

- Leading Edge Acceleration Projects (LEAP) in Health IT: Address fast emerging challenges that inhibit the development, use, and advancement of interoperable health IT. *ONC*
- IDEA2Health: Innovative Data Evaluation and Analysis to Health: Stimulate research and advancement of methodologies in data science in heart, lung, blood, or sleep biomedical research, and ultimately translate new insights into decision-making to improve health. *NIH*
- Open Knowledge Network Initiative. *NSF*

3. Support the integration & use of digital health tools, devices, and solutions within the healthcare and public health surveillance ecosystem to prevent and predict pandemics and understand and mitigate the impacts of changes in climate and the environment on health.

- Expanding Climate Change and Health Data Infrastructure to Advance Health Interventions: Linking Health and Environmental Data to Improve Patient and Community Health. *AHRQ, NASA, NIH*
- Telehealth Test-to-Treat Program. *ASPR, HHS, NIH*
- Semantic Interoperability of Medical Devices. *FDA, NLM, NIST*
- Predictive Intelligence for Pandemic Prevention: LEAP in Health IT: Better understand the dynamic nature of pathogen and disease emergencies, which poses a continuing risk to our national security, health, and economic stability. *CDC, NSF*
- Enabling Visual Communication Technologies for the Internet of Things in Healthcare. *NIST*
- The Role of Telehealth in COVID-19 Response: Use a nationwide information system of telehealth services and insurance claims to analyze the response and impact of the COVID-19 pandemic to improve readiness for future public health emergencies. *AHRQ*

4. Promote accelerated innovation in the community via dissemination of regulatory, analytic, and information science tools to facilitate understanding and decisions affecting the digital health R&D of products that improve health and expand the U.S. bioeconomy.

- Air You Wear Challenge Prize. *CMS, FDA, NIH, NSF*
- Image-Based Quality control of Retinal Pigment Epithelial Implants. *NEI NIH, NIST*
- Interoperability of Software Plugins and Computational Provenance for Cloud Computing. *NCATS NIH, NIST*
- Medical Device Development Tools (SBIR). *FDA, NIH*
- NIST Tools for Searching the COVID-19 Dataset. *NIST*
- Regional Innovation Engines. *NSF*
- Smart Health Care: Toward P9 Medicine. *NIST*
- America's Seed Fund (SBIR and STTR): Digital Health and Biological Technologies. *NSF*

5. Develop appropriate privacy-preserving, secure methods and data transfer strategies, and support implementation of standards and certification to enhance trust and confidence in health and biomedical systems.

- Mitigating Cybersecurity Risk in Telehealth Smart Home Integration: Provide healthcare delivery organizations with solutions for a secure ecosystem that incorporates consumer-owned smart devices into a telehealth solution. *NIST, industry partners*

- RADx Mobile Application Reporting through Standards and Working with SARS-CoV-2 test manufactures to drive adoption. *NIH, ONC*
- Securing Telehealth Remote Patient Monitoring Ecosystem: Cybersecurity for the Healthcare Sector: Provide a practical solution for securing the telehealth remote patient monitoring ecosystem. *NIST, industry partners*
- Mitigating Cybersecurity Risk in AI Enabled Healthcare Applications. *NIST, industry partners*
- Cybersecurity of Genomic Data. *NIST*
- NIH Data Management and Sharing Policy and NIH Genomic Data Sharing Policy. *NIH*
- Secure and Trustworthy Cyberspace (SaTC). *NSF*
- Using Machine Learning Techniques to Enable Health Information Exchange to Support COVID-19-Focused Patient-Centered Outcome Research: Upgrade the health information exchange infrastructure by implementing a nationally recognized data standard and facilitating efficient data access for health systems and providers; test the use of split learning to facilitate privacy-preserving data sharing; and disseminate the resulting resources and lessons learned to support the adoption of data standards, technology, and methods. *ONC*

4.1.2 Key Coordination Activities

- Advance the use of digital health tools and technologies in healthcare. *All DHRD agencies*
- Coordinate digital health and health-IT programs and activities related to the COVID-19 pandemic. *All DHRD agencies*
- Digital Health Lessons Learned During COVID-19 Workshop. *All DHRD agencies*
- Implement the 2020–2025 Federal Health IT Strategic Plan: Follow this Federal Government guidance for using health IT to promote secure access of all parties to electronic health information to improve patient health, including through education and training programs. *All DHRD agencies*
- Federal Health IT Coordinating Council Commerce. *CDC, DHS, DOC, DOD, DOJ, FDA, FCC, FTC, NASA, NIH, NIST, NSF, OPM, ONC, SSA, VA*
- BIO+AI Community of Practice: Establish best practices for sharing data and making it AI accessible. *DOC, DOD, DOE, NASA, NIST, NSF, USDA*
- Health IT Advisory Committee. *FDA, NIH, NIST, ONC, VA*
- NSF-NIH interagency solicitations. *NIH, NSF*
- CPS: Enable capability, adaptability, scalability, resiliency, safety, security, and usability that will expand the horizons of critical systems. *NIH, NSF*
- Smart and Connected Health: Accelerate development and use of next-generation healthcare solutions. *NIH, NSF*

4.2 Digital Assets R&D (DARD) Fast-Track Action Committee (FTAC)

In October 2022, OSTP charged NITRD to create a DARD FTAC, with membership across the Federal Government, to develop the National Digital Assets R&D Agenda. The DARD FTAC

published a report *National Objectives for Digital Assets R&D*²⁴ that lays out national objectives for R&D related to digital assets, as defined in *President Biden's Executive Order on Ensuring the Responsible Development of Digital Assets*.²⁵ These national objectives will be expanded upon in the forthcoming final R&D agenda to advance foundational, applied, and translational R&D related to digital assets.

4.3 Information Integrity R&D (IIRD) IWG

The Information Integrity Research and Development Interagency Working Group (IIRD IWG) was formed in 2021 to provide a forum for interagency coordination on research and development investments in information integrity. The IIRD IWG aims to identify research gaps, define future research directions, enable opportunities for interagency collaborations and investments, encourage public-private partnerships, and disseminate research results. The IIRD IWG developed an action plan to address these priorities, *Roadmap for Researchers on Priorities Related to Information Integrity R&D*.²⁶

²⁴ <https://www.nitrd.gov/pubs/National-Objectives-for-Digital-Assets-Research-and-Development.pdf>.

²⁵ White House. (2022, March 9). Executive Order on Ensuring Responsible Development of Digital Assets. <https://www.whitehouse.gov/briefing-room/presidential-actions/2022/03/09/executive-order-on-ensuring-responsible-development-of-digital-assets>.

²⁶ <https://www.nitrd.gov/pubs/Roadmap-Information-Integrity-RD-2022.pdf>

5.0 Overview of the National Artificial Intelligence Research Institutes

5.1 Introduction

Congress passed the National Artificial Intelligence Initiative Act (NAIIA) of 2020 to establish advances in AI that strengthen innovation across multiple sectors, such as health, education, manufacturing, agriculture, security, energy, and environment.

The NAIIA calls for NSF to lead Federal agencies in providing investments to jump-start these innovations through National AI Research Institutes ("AI Institutes"). The investments address sector-specific or cross-cutting challenges (e.g., trustworthiness) relevant to the application of AI in those sectors or in AI systems broadly and has the potential to translate the research into products, applications, and services.

The NAIIA requires, among other provisions, that the AI Institutes be formed among multi-dimensional partnerships of public and private entities; address the ethical, societal, safety, and security implications of AI R&D; and support interdisciplinary R&D across multiple institutions of higher education, development of interdisciplinary education activities, and development of an AI workforce across all U.S. communities, including those that are historically underrepresented in S&T.

The AI Institutes Virtual Organization²⁷ serves to connect and support the institutes in a variety of ways as they carry out a broad spectrum of research of critical importance to U.S. competitiveness, food security, public safety and education, and myriad other targets.

This section serves as the FY 2024 annual report on the status of the AI Institutes as called for in the National Artificial Intelligence Initiative Act of 2020. The lead agencies NSF and NIFA, together with other partners, have funded 25 AI institutes. The following subsections provide an overview of the AI Institutes launched to date. [Table 2](#) in [Section 2.0](#) provides the actual, enacted, and requested investments by Federal agencies for these AI Institutes for FYs 2022–2024.

5.2 National AI Research Institutes

The AI Institutes program is NSF's flagship program for use-inspired AI research, and it is the U.S.'s largest AI research ecosystem funded through partnerships between Federal agencies and industry leaders.

The program launched with a cohort of seven AI Institutes in 2020,²⁸ and eleven more were announced in 2021.²⁹ In 2023, NSF announced³⁰ seven new Institutes, bringing the total investment in these AI Institutes to \$500 billion and a network of over 500 funded and collaborative institutions across the U.S. and around the world. Unless otherwise noted, the AI Institute is funded by NSF.

²⁷ <https://aiinstitutes.org/>

²⁸ <https://new.nsf.gov/science-matters/new-nsf-ai-research-institutes-push-forward>

²⁹ <https://new.nsf.gov/science-matters/expanding-geography-innovation-nsf-ai-research>

³⁰ <https://new.nsf.gov/news/nsf-announces-7-new-national-artificial>

5.2.1 *AI Institute for Adult Learning and Online Education (ALOE)*

Year Launched	2021		
Focus	<p>Led by the Georgia Research Alliance, this institute, also known as ALOE, will lead the country and the world in the development of novel AI theories and techniques for enhancing the quality of adult online education, making this mode of learning comparable to that of in-person education in STEM disciplines. Fundamental research in use-inspired AI is grounded in theories of human cognition and learning supported by evidence from large-scale data, evaluated on a large variety of testbeds, and derived from the scientific process of learning engineering. Together with partners in the technical college systems and educational technology sector, ALOE will advance online learning using virtual assistants to make education more available, affordable, achievable, and ultimately, more equitable.</p> <p>This institute is funded by a partnership between NSF and Accenture.</p>		
Funding	For information on funding, please see https://www.nsf.gov/awardsearch/showAward?AWD_ID=2112532 .	Primary Organization	Georgia Research Alliance
Other Principal Organizations			
• Georgia Institute of Technology		• Technical College System of Georgia	• Harvard University
• Georgia State University		• University of North Carolina Greensboro	
More information	https://aialoe.org/		

5.2.2 *AI Institute for Advances in Optimization (AI4OPT)*

Year Launched	2021		
Focus	<p>Led by the Georgia Institute of Technology, this institute will revolutionize decision-making on a large scale by fusing AI and mathematical optimization into intelligent systems that will achieve breakthroughs that neither field can achieve independently. The institute will create pathways from high school to undergraduate and graduate education and workforce development training for AI in engineering that will empower a generation of underrepresented students and teachers to join the AI revolution. It will also create a sustainable ecosystem for AI, combining education, research, entrepreneurship, and the public at large. The institute will demonstrate foundational advances on use cases in energy, resilience and sustainability, supply chains, and circuit design and control. It has innovative plans for workforce education and broadening participation, including substantial leadership from a collaborating minority-serving institution.</p> <p>This institute is funded by a partnership between NSF and Intel.</p>		
Funding	For information on funding, please see https://www.nsf.gov/awardsearch/showAward?AWD_ID=2112533 .	Primary Organization	Georgia Institute of Technology
Other Principal Organizations			
• Clark Atlanta University		• University of California, San Diego	• The University of Texas at Arlington
• University of California, Berkeley		• University of Southern California	
More information	https://www.ai4opt.org/		

5.2.3 *NEW AI Institute for Agent-based Cyber Threat Intelligence and Operation (ACTION)*

Year Launched	2023		
Focus	<p>Led by the University of California, Santa Barbara, this institute will develop novel approaches that leverage AI to anticipate and take corrective actions against cyberthreats that target the security and privacy of computer networks and their users. The team of researchers will work with experts in security operations to develop a revolutionary approach to cybersecurity, in which AI-enabled intelligent security agents cooperate with humans across the cyberdefense life cycle to jointly improve the resilience of security of computer systems over time.</p> <p>This institute is funded by a partnership between NSF, DHS-S&T, and IBM.</p>		
Funding	For information on funding, please see https://www.nsf.gov/awardsearch/showAward?AWD_ID=2229876 .	Primary Organization	University of California, Santa Barbara
Other Principal Organizations			
	• Georgia Tech Research Corporation	• Rutgers University	• University of Virginia
	• Multi-Campus University of California Berkeley Award	• University of Chicago	• University of Washington
	• Norfolk State University	• University of Illinois Chicago	
	• Purdue University	• University of Illinois Urbana-Champaign	
More information	https://action.ucsb.edu/		

5.2.4 *AI Institute for Agricultural AI for Transforming Workforce and Decision Support (AgAID)*

Year Launched	2021			
Focus	<p>Led by Washington State University, this institute, also known as AgAID, will integrate AI methods into agriculture operations for prediction, decision support, and robotics-enabled agriculture to address complex agricultural challenges. The AgAID Institute uses a unique adopt-adapt-amplify approach to develop and deliver AI solutions to agriculture that address pressing challenges related to labor, water, weather and climate change. The institute involves farmers, workers, managers and policy makers in the development of these solutions, as well as in AI training and education, which promotes equity by increasing the technological skill levels of the next-generation agricultural workforce.</p> <p>This institute is funded by NIFA.</p>			
Funding (in millions)	FY 2022	FY 2023	FY 2024	Primary Organization
	4.0	4.0	4.0	Washington State University
Other Principal Organizations				
	• Carnegie Mellon University	• Kansas State University	• University of Virginia	
	• Heritage University	• Oregon State University	• Wenatchee Valley College	
	• Innov8.Ag	• University of California, Merced		
More information	https://agaid.wsu.edu/			
Note: For the FY columns, FY 2022 refers to actual budget, FY 2023 refers to planned budget, and FY 2024 refers to budget request.				

5.2.5 *NEW AI Institute for Artificial and Natural Intelligence (ARNI)*

Year Launched	2023		
Focus	Led by Columbia University, this institute will draw together top researchers across the country to focus on a national priority: connecting the major progress made in AI systems to the revolution in our understanding of the brain. ARNI will meet the urgent need for new paradigms of interdisciplinary research between neuroscience, cognitive science and AI. This will accelerate progress in all three fields and broaden the transformative impact on society in the next decade. This institute is funded by a partnership between NSF and OUSD(R&E).		
Funding	For information on funding, please see https://www.nsf.gov/awardsearch/showAward?AWD_ID=2229929 .	Primary Organization	Columbia University
Other Principal Organizations			
	• Baylor College of Medicine	• Harvard University	• University of Pennsylvania
	• City University of New York Graduate Center	• New York Hall of Science	• Yale University
	• Hunter College	• Tuskegee University	
More information	https://www.engineering.columbia.edu/news/columbia-university-artificial-and-natural-intelligence-nsf-ai-institute		

5.2.6 *AI Institute for Artificial Intelligence and Fundamental Interactions (IAIFI)*

Year Launched	2020		
Focus	Led by the Massachusetts Institute of Technology, this institute will, among other things, work to build AI methods that incorporate basic physics principles, making data-analysis choices more targeted. They'll explore the synergies between physics concepts and AI to improve basic understanding of AI techniques and how the techniques can help improve things such as neural network architectures—the basic building blocks of advanced machine learning. Building physics concepts into AI techniques will also assist physicists in performing difficult and sometimes intractable calculations, which in turn will serve as a framework for discovery. Since new insights often emerge from deviations in data, when things don't look as expected, AI methods that are fine-tuned to look at physical systems will be able to quickly identify these outliers—potentially speeding the process of discovery.		
Funding	For information on funding, please see https://www.nsf.gov/awardsearch/showAward?AWD_ID=2019786 .	Primary Organization	Massachusetts Institute of Technology
Other Principal Organizations			
	• Harvard University	• Northeastern University	• Tufts University
More information	https://iaifi.org/		

5.2.7 *NEW AI Institute for Climate-Land Interactions, Mitigation, Adaptation, Tradeoffs, and Economy (AI-CLIMATE)*

Year Launched	2023		
Focus	<p>Led by the University of Minnesota Twin Cities, this institute aims to advance foundational AI by incorporating knowledge from agriculture and forestry sciences and leveraging these unique, new AI methods to curb climate effects while lifting rural economies. By creating a new scientific discipline and innovative ecosystem intersecting AI and climate-smart agriculture and forestry, our researchers and practitioners will discover and invent compelling AI-powered knowledge and solutions. Examples include AI-enhanced estimation methods of greenhouse gases and specialized field-to-market decision support tools. A key goal is to lower the cost of and improve accounting for carbon in farms and forests to empower carbon markets and inform decision making. The institute will also expand and diversify rural and urban AI workforces.</p> <p>This institute is funded by NIFA.</p>		
Funding	For information on funding, please see https://portal.nifa.usda.gov/web/crisprojectpages/1030594-ai-climate-ai-institute-for-climate-land-interactions-mitigation-adaptation-tradeoffs-and-economy.html .	Primary Organization	University of Minnesota Twin Cities
Other Principal Organizations			
• Cornell University	• Delaware State University	• North Carolina State University	
• Colorado State University Global	• Purdue University	• International Soil Reference and Information Center	
More information	https://twin-cities.umn.edu/news-events/u-m-lead-new-ai-institute-focusing-climate-smart-agriculture-and-forestry		

5.2.8 *AI Institute for Collaborative Assistance and Responsive Interaction for Networked Groups (AI-CARING)*

Year Launched	2021		
Focus	<p>Led by the Georgia Institute of Technology, this institute, also known as AI-CARING, will seek to create a vibrant, fully developed discipline focused on personalized, longitudinal (over months and years) collaborative AI systems that learn individual models of human behavior and how they change over time and use that knowledge to better collaborate and communicate in caregiving environments. The collaborative AI Partners in Care developed as part of this institute will help support a growing population of older adults sustain independence, improve quality of life, and increase effectiveness of care coordination across the care network.</p> <p>This institute is funded by a partnership between NSF, Amazon, and Google.</p>		
Funding	For information on funding, please see https://www.nsf.gov/awardsearch/showAward?AWD_ID=2112633	Primary Organization	Georgia Institute of Technology
Other Principal Organizations			
• Carnegie Mellon University	• Oregon Health & Science University	• Oregon State University	
More information	https://ai-caring.org/		

5.2.9 AI Institute in Dynamic Systems

Year Launched	2021		
Focus	<p>Led by the University of Washington, this institute will enable innovative research and education in fundamental AI and machine learning theory, algorithms and applications specifically for safe, real-time learning and control of complex dynamic systems. The core motivation for this institute is to integrate physics-based models with AI and machine learning approaches, leading the way towards data-enabled ethical, efficient, and explainable solutions for real-time sensing, prediction, and decision-making challenges across science and engineering.</p> <p>This institute is funded by a partnership between NSF and DHS.</p>		
Funding	For information on funding, please see https://www.nsf.gov/awardsearch/showAward?AWD_ID=2112085 .	Primary Organization	University of Washington
Other Principal Organizations			
	• Boise State University	• Montana State University	• University of Alaska
	• Columbia University	• Portland State University	• University of Hawaii
	• Harvard University	• Seattle University	• University of Nevada, Reno
More information	https://dynamicsai.org/		

5.2.10 AI Institute for Edge Computing Leveraging Next-Generation Networks (Athena)

Year Launched	2021		
Focus	<p>Led by Duke University, this institute, also known as Athena, will focus on developing edge computing with groundbreaking AI functionality while keeping complexity and costs under control. Bringing together a world-class, multidisciplinary team of scientists, engineers, statisticians, legal scholars and psychologists from seven universities, it will transform the design, operation and service of future systems from mobile devices to networks. It is committed to educating and developing the workforce, cultivating a diverse next generation of edge computing and network leaders whose core values are driven by ethics and fairness in AI. As a nexus point for the community, this institute will spearhead collaboration and knowledge transfer, translating emerging technical capabilities to new business models and entrepreneurial opportunities.</p> <p>This institute is funded by a partnership between NSF and DHS.</p>		
Funding	For information on funding, please see https://www.nsf.gov/awardsearch/showAward?AWD_ID=2112562 .	Primary Organization	Duke University
Other Principal Organizations			
	• Arizona State University	• University of Illinois Chicago	• University of Wisconsin-Madison
	• Massachusetts Institute of Technology	• University of Illinois Urbana-Champaign	• Yale University
	• North Carolina A&T	• University of Michigan	
	• Princeton University	• University of Washington	
More information	https://athena.duke.edu/		

5.2.11 AI Institute for Engaged Learning (ENGAGE AI)

Year Launched	2021		
Focus	Led by North Carolina State University, this institute will advance natural language processing, computer vision and machine learning to engage learners in AI-driven narrative-centered learning environments. Rich AI-driven virtual agents and powerful multimodal sensing capabilities will support learners and yield transformative advances in STEM teaching and learning. The institute will serve as a nexus for in-school and out-of-school STEM education innovation, empowering and engaging diverse learners and stakeholders to ensure that AI-driven learning environments are ethically designed to promote equity and inclusion.		
Funding	For information on funding, please see https://www.nsf.gov/awardsearch/showAward?AWD_ID=2112635 .	Primary Organization	North Carolina State University
Other Principal Organizations			
• Digital Promise Global		• The University of North Carolina at Chapel Hill	
• Indiana University		• Vanderbilt University	
More information	https://www.aiengage.org/		

5.2.12 NEW AI Institute for Exceptional Education (AI4ExceptionalEd)

Year Launched	2023		
Focus	Led by the University at Buffalo, this institute will work toward universal speech and language screening for children. The framework, the AI screener, will analyze video and audio streams of children during classroom interactions and assess the need for evidence-based interventions tailored to individual needs of students. The institute will serve children in need of ability-based speech and language services, advance foundational AI technologies and enhance understanding of childhood speech and language development. The AI Institute for Exceptional Education was previously announced in January 2023. This institute is funded by a partnership between NSF and ED-IES.		
Funding	For information on funding, please see https://www.nsf.gov/awardsearch/showAward?AWD_ID=2229873 .	Primary Organization	University at Buffalo
Other Principal Organizations			
• Cornell University		• University of Nevada, Reno	• University of Oregon
• Pennsylvania State University		• The University of Texas at El Paso	
• Stanford University		• University of Washington	
More information	https://www.buffalo.edu/ai4exceptionaled.html		

5.2.13 AI Institute for Foundations of Machine Learning

Year Launched	2020		
Focus	Led by the University of Texas at Austin this Institute will dedicate research efforts to addressing fundamental challenges and applications in machine learning that will underpin the development of safer and more reliable AI applications such as self-driving cars and many others. A key challenge is to build new, more efficient deep learning algorithms that can account for constantly evolving data and can incorporate changing contexts—in much the same way your brain is able to react and adjust course when it anticipates a hazard while driving. There are still many fundamental mysteries that remain when it comes to understanding exactly how these deep learning neural networks function. The team will work toward new theories that rigorously explain how algorithms successfully achieve optimal solutions in practice despite conventional statistical methods suggesting that they should not. New theories are also needed to produce reliable algorithms suitable for use in mission-critical and safety-critical applications. The institute will tackle these challenges among many others.		
Funding	For information on funding, please see https://www.nsf.gov/awardsearch/showAward?AWD_ID=2019844 .	Primary Organization	The University of Texas at Austin
Other Principal Organizations			
• Texas Advanced Computing Center		• University of Washington	
• The University of Texas at Austin, Dell Medical School		• Wichita State University	
More information	https://www.ifml.institute/		

5.2.14 AI Institute for Future Agricultural Resilience, Management, and Sustainability (AIFARMS)

Year Launched	2020			
Focus	Led by the University of Illinois Urbana-Champaign, this institute will advance AI research in computer vision, machine learning, soft object manipulation, and intuitive human-robot interaction to solve major agricultural challenges including labor shortages, efficiency and welfare in animal agriculture, environmental resilience of crops, and the need to safeguard soil health. The Institute features a new joint Computer Science + Agriculture degree and global clearinghouse to foster collaboration in AI-driven agriculture research. This institute is funded by NIFA.			
Funding (in millions)	FY 2022	FY 2023	FY 2024	Primary Organization
	4.0	4.0	4.0	University of Illinois Urbana-Champaign
Other Principal Organizations				
• Donald Danforth Plant Science Center			• Tuskegee University	
• Michigan State University			• University of Chicago	
More information	https://aifarms.illinois.edu/			
Note: For the FY columns, FY 2022 refers to actual budget, FY 2023 refers to planned budget, and FY 2024 refers to budget request.				

5.2.15 AI Institute for Future Edge Networks and Distributed Intelligence (AI-EDGE)

Year Launched	2021		
Focus	<p>Led by The Ohio State University, this institute, also known as AI-EDGE, will leverage the synergies between networking and AI to design future generations of wireless edge networks that are highly efficient, reliable, robust and secure. New AI tools and techniques will be developed to ensure that these networks are self-healing and self-optimized. Collaboration over these adaptive networks will help solve long-standing distributed AI challenges making AI more efficient, interactive, and privacy preserving for applications in sectors such as intelligent transportation, remote health care, distributed robotics and smart aerospace. It will create a research, education, knowledge transfer and workforce development environment that will help establish U.S. leadership in next-generation edge networks and distributed AI for many decades to come.</p> <p>This institute is funded by a partnership between NSF and DHS-S&T.</p>		
Funding	For information on funding, please see https://www.nsf.gov/awardsearch/showAward?AWD_ID=2112471 .	Primary Organization	The Ohio State University
Other Principal Organizations			
• Carnegie Mellon University	• University of Illinois Urbana-Champaign	• University of Washington	
• Northeastern University	• University of Massachusetts Amherst	• University of Wisconsin-Madison	
• Purdue University	• University of Michigan		
• University of Illinois Chicago	• The University of Texas at Austin		
More information	https://aiedge.osu.edu/		

5.2.16 NEW AI Institute for Inclusive Intelligent Technologies for Education (INVITE)

Year Launched	2023		
Focus	<p>Led by the University of Illinois Urbana-Champaign, this institute seeks to fundamentally reframe how educational technologies interact with learners by developing AI tools and approaches to support three crucial noncognitive skills known to underlie effective learning: persistence, academic resilience and collaboration. The institute's use-inspired research will focus on how children communicate STEM content, how they learn to persist through challenging work, and how teachers support and promote noncognitive skill development. The resultant AI-based tools will be integrated into classrooms to empower teachers to support learners in more developmentally appropriate ways.</p> <p>This institute is funded by a partnership between NSF and ED-IES.</p>		
Funding	For information on funding, please see https://www.nsf.gov/awardsearch/showAward?AWD_ID=2229612 .	Primary Organization	University of Illinois Urbana-Champaign
Other Principal Organizations			
• Balance Studios	• University of Florida	• University of Southern California	
• Educational Testing Service	• University of Michigan	• Wright State University	
• Temple University	• University of Oregon		
More information	https://invite.illinois.edu/		

5.2.17 AI Institute for Intelligent Cyberinfrastructure with Computational Learning in the Environment (ICICLE)

Year Launched	2021		
Focus	Led by The Ohio State University, this institute will build the next generation of cyberinfrastructure that will make AI easy for scientists to use and promote its further democratization. This institute aims to transform the AI landscape of today by bringing in scientists from multidisciplinary backgrounds to create a robust, trustworthy, and transparent national cyberinfrastructure that is ready to "plug-and-play" in areas of societal importance such as "smart food sheds," precision agriculture, and animal ecology. The Institute will develop a new generation of the workforce with sustained diversity and inclusion at all levels.		
Funding	For information on funding, please see https://www.nsf.gov/awardsearch/showAward?AWD_ID=2112606 .	Primary Organization	The Ohio State University
Other Principal Organizations			
<ul style="list-style-type: none"> Case Western Reserve University 	<ul style="list-style-type: none"> Rensselaer Polytechnic Institute 	<ul style="list-style-type: none"> University of California, San Diego 	
<ul style="list-style-type: none"> International Center for Food Ontology Operability Data and Semantics 	<ul style="list-style-type: none"> San Diego Supercomputer Center Ohio Supercomputer Center 	<ul style="list-style-type: none"> University of Delaware 	
<ul style="list-style-type: none"> Indiana University 	<ul style="list-style-type: none"> Texas Advanced Computing Center 	<ul style="list-style-type: none"> University of Utah 	
<ul style="list-style-type: none"> Iowa State University 	<ul style="list-style-type: none"> University of California, Davis 	<ul style="list-style-type: none"> University of Wisconsin-Madison 	

5.2.18 AI Institute for Learning-Enabled Optimization at Scale (TILOS)

Year Launched	2021		
Focus	Led by the University of California San Diego, in collaboration with five other universities across the nation, this institute, also known as TILOS, aims to "make impossible optimizations possible" by addressing the fundamental challenges of scale and complexity. Learning-enabled optimization will be applied in several technical focus areas vital to the nation's health and prosperity, including semiconductor chip design, robotics and networks. The research agenda is accompanied by plans for workforce development and broadening participation at all academic levels, from middle school to advanced research levels, including community outreach efforts to promote AI. This institute is funded by a partnership between NSF and Intel.		
Funding	For information on funding, please see https://www.nsf.gov/awardsearch/showAward?AWD_ID=2112665 .	Primary Organization	University of California, San Diego
Other Principal Organizations			
<ul style="list-style-type: none"> Massachusetts Institution of Technology 	<ul style="list-style-type: none"> University of Pennsylvania 	<ul style="list-style-type: none"> Yale University 	
<ul style="list-style-type: none"> National University 	<ul style="list-style-type: none"> The University of Texas at Austin 		
More information	https://tilos.ai/		

5.2.19 AI Institute for Molecular Discovery, Synthetic Strategy, and Manufacturing (Molecule Maker Lab Institute or MMLI)

Year Launched	2020		
Focus	Led by the University of Illinois Urbana-Champaign, this institute will develop new AI-enabled tools to accelerate automated chemical synthesis and advance the discovery and manufacture of novel materials and bioactive compounds. The Institute also serves as a training ground for the next generation of scientists with combined expertise in AI, chemistry, and bioengineering.		
Funding	For information on funding, please see https://www.nsf.gov/awardsearch/showAward?AWD_ID=2019897 .	Primary Organization	University of Illinois Urbana-Champaign
Other Principal Organizations			
	• Colorado State University Global		• Pennsylvania State University
	• Georgia Institute of Technology		• Rochester Institute of Technology
	• Indiana University		• University of California, Santa Barbara
More information	https://moleculemaker.org/		

5.2.20 AI Institute for Next-Generation Food Systems (AIFS)

Year Launched	2020			
Focus	Led by the University of California, Davis, this institute will integrate a holistic view of the food system with AI and bioinformatics to understand biological data and processes, addressing issues of molecular breeding to optimize traits for yield, crop quality, and pest or disease resistance, agricultural production, food processing and distribution, and nutrition. Major emphasis is on inclusive education and outreach approaches to build a diverse, next-generation workforce.			
	This institute is funded by NIFA.			
Funding (in millions)	FY 2022	FY 2023	FY 2024	Primary Organization
	4.0	4.0	4.0	University of California, Davis
Other Principal Organizations				
	• Cornell University			• University of California, Berkeley
	• Duke University			• University of Illinois Urbana-Champaign
	• University of California, Agriculture and Natural Resources			
More information	https://aifs.ucdavis.edu/			
Note: For the FY columns, FY 2022 refers to actual budget, FY 2023 refers to planned budget, and FY 2024 refers to budget request.				

5.2.21 AI Institute for Research in Trustworthy AI in Weather, Climate, and Coastal Oceanography (AI2ES)

Year Launched	2020		
Focus	Led by the University of Oklahoma, this institute will work to improve the accuracy and reliability—or trustworthiness—of AI techniques that underpin crucial weather models and predictions. The institute will conduct fundamental research into better understanding how AI algorithms transform raw data from extremely large and varied data sets into actionable guidance and predictions; this research will help scientists better communicate to the public the associated levels of accuracy and reliability. The institute will also offer AI training certificates to help cultivate an AI-trained workforce.		
Funding	For information on funding, please see https://www.nsf.gov/awardsearch/showAward?AWD_ID=2019758 .	Primary Organization	The University of Oklahoma
Other Principal Organizations			
	• Central Michigan University	• North Carolina State University	• University of Washington
	• Colorado State University Global	• Texas A&M University-Corpus Christi	• University Corporation for Atmospheric Research
	• Del Mar College	• University at Albany	
More information	https://www.ai2es.org/		

5.2.22 Resilient Agriculture (AIIRA)

Year Launched	2021		
Focus	Led by Iowa State University, this institute, also known as AIIRA, will transform agriculture through innovative AI-driven digital twins that model plants at an unprecedented scale. This approach is enabled by advances in computational theory, AI algorithms, and tools for crop improvement and production for resiliency to climate change. In addition, AIIRA will promote the study of cyber-agricultural systems at the intersection of plant science, agronomics, and AI; power education and workforce development through formal and informal educational activities, focusing on Native American bidirectional engagement and farmer programs; and drive knowledge transfer through partnerships with industry, producers, and federal and state agencies. This institute is funded by NIFA.		
Funding (in millions)	FY 2022	FY 2023	FY 2024
	4.0	4.0	4.0
	Primary Organization		Iowa State University
Other Principal Organizations			
	• Carnegie Mellon University	• New York University	• University of Missouri
	• George Mason University	• University of Arizona	• University of Nebraska-Lincoln
	• Iowa Soybean Association		
More information	https://aiira.iastate.edu/		
Note: For the FY columns, FY 2022 refers to actual budget, FY 2023 refers to planned budget, and FY 2024 refers to budget request.			

5.2.23 NEW AI Institute for Societal Decision Making (AI-SDM)

Year Launched	2023		
Focus	Led by Carnegie Mellon University, this institute seeks to create human-centric AI for decision making to bolster effective response in uncertain, dynamic and resource-constrained scenarios like disaster management and public health. By bringing together an interdisciplinary team of AI and social science researchers, AI-SDM will enable emergency managers, public health officials, first responders, community workers and the public to make decisions that are data driven, robust, agile, resource efficient and trustworthy. The vision of the institute will be realized via development of AI theory and methods, translational research, training and outreach, enabled by partnerships with diverse universities, government organizations, corporate partners, community colleges, public libraries and high schools.		
Funding	For information on funding, please see https://www.nsf.gov/awardsearch/showAward?AWD_ID=2229881 .	Primary Organization	Carnegie Mellon University
Other Principal Organizations			
• Boston Children’s Hospital	• MITRE Corporation VA	• Texas A&M University	
• Harvard University	• Navajo Technical University	• University of Washington	
• Howard University	• Pennsylvania State University		
More information	https://www.cmu.edu/news/stories/archives/2023/may/carnegie-mellon-leads-nsf-ai-institute-for-societal-decision-making		

5.2.24 AI Institute for Student-AI Teaming (iSAT)

Year Launched	2020		
Focus	Led by the University of Colorado Boulder, this institute will focus research on developing “AI partners” that will facilitate collaborative learning by interacting naturally through speech, gesture, gaze, and facial expression in classrooms. With growing classroom sizes and online learning, it becomes increasingly difficult for teachers to offer individualized instruction. AI partners, however, will be trained to assist by recognizing facial expressions and gestures to gauge interest and engagement as well as inferring from group discussions which students might feel excluded from conversations.		
Funding	For information on funding, please see https://www.nsf.gov/awardsearch/showAward?AWD_ID=2019805 .	Primary Organization	University of Colorado Boulder
Other Principal Organizations			
• Arizona State University	• Georgia Institute of Technology	• University of Illinois Urbana-Champaign	
• Brandeis University	• University of California, Berkeley	• University of Wisconsin-Madison	
• Colorado State University Global	• University of California, Santa Cruz	• Worcester Polytechnic Institute	
More information	https://www.colorado.edu/research/ai-institute/		

5.2.25 NEW AI Institute for Trustworthy AI in Law and Society (TRAILS)

Year Launched	2023		
Focus	Led by the University of Maryland, this institute, also known as TRAILS, aims to transform the practice of AI from one driven primarily by technological innovation to one driven with attention to ethics, human rights, and support for communities whose voices have been marginalized into mainstream AI. TRAILS will be the first Institute of its kind to integrate participatory design, technology, and governance of AI systems and technologies and will focus on investigating what trust in AI looks like, whether current technical solutions for AI can be trusted, and which policy models can effectively sustain AI trustworthiness. This institute is funded by a partnership between NSF and NIST		
Funding	For information on funding, please see https://www.nsf.gov/awardsearch/showAward?AWD_ID=2229885 .	Primary Organization	University of Maryland
Other Principal Organizations			
• Cornell University		• The George Washington University	• Morgan State University
More information	https://www.trails.umd.edu/		

Appendix A. List of Abbreviations and Acronyms

Acronym	Definition
ACL	Administration for Community Living
ACNS	Advanced Communication Networks and Systems
AFOSR	Air Force Office of Scientific Research (DOD)
AFRI	Agriculture and Food Research Initiative (USDA)
AFRL	Air Force Research Laboratory (DOD)
AgAID	Agricultural AI for Transforming Workforce and Decision Support
AHRQ	Agency for Healthcare Research and Quality (HHS)
AI	Artificial Intelligence
AI/ML	Artificial Intelligence and Machine Learning
AI2ES	AI Institute for Artificial Intelligence for Environmental Sciences
AI4Opt	NSF AI Institute for Advances in Optimization
AI-ALOE	National AI Institute for Adult Learning and Online Education
AI-CARING	AI Institute for Collaborative Assistance and Responsive Interaction for Networked Groups
AI-EDGE	NSF AI Institute for Future Edge Networks and Distributed Intelligence
AIFARMS	Artificial Intelligence for Future Agricultural Resilience, Management, and Sustainability
AIFS	AI Institute for Next Generation Food Systems
AIIRA	AI Institute for Resilient Agriculture
ANSI	American National Standards Institute
AR	Augmented Reality
ARL	Army Research Laboratory
ARO	Army Research Office
ARPA-E	Advanced Research Projects Agency-Energy
ARS	Agricultural Research Service (USDA)
AWRD	Advanced Wireless R&D (ACNS sub-PCA)
BD	Big Data
BSEE	Bureau of Safety and Environmental Enforcement (DOI)
C5ISR	Army-Command, Control, Communication, Computers, Cyber, Intelligence, Surveillance and Reconnaissance Center
CCDC	Combat Capabilities Development Command - DEVCOM
CDC	Centers for Disease Control and Prevention
CDS	Clinical Decision Support
CDS&E	Computational and Data-Enabled Science and Engineering
CDSiC	Clinical Decision Support Innovation Collaborative
Census	U.S. Census Bureau
CHuman	Computing-Enabled Human Interaction, Communication, and Augmentation
CIA	Central Intelligence Agency
CISA	Cybersecurity and Infrastructure Security Agency
CISE	Computer and Information Science and Engineering

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Acronym	Definition
CMS	Centers for Medicare and Medicaid Services
CNPS	Computing-Enabled Networked Physical Systems
CPS	Cyber-Physical Systems
CSIA	Cyber Security and Information Assurance
CSP	Cyber Security and Privacy
CSSI	Cyberinfrastructure for Sustained Scientific Innovation
DAF	Department of the Air Force
DARPA	Defense Advanced Research Projects Agency
DEVCOM	U.S. Army Combat Capabilities Development Command (DEVCOM)
DevSecOps	Development Security Operations
DHRD	Digital Health Research and Development
DHS	Department of Homeland Security
DHS/CWMD	Department of Homeland Security Counter Weapons of Mass Destruction Office
DHS/S&T	Department of Homeland Security Science and Technology Directorate
DHS/TSA	Department of Homeland Security Transportation Security Administration
DISA	Defense Information Systems Agency
DOC	Department of Commerce
DOD	Department of Defense
DOD/CIO	Department of Defense Chief Information Officer
DOD/HPCMP	Department of Defense High Performance Computing Modernization Program
DOE	Department of Energy
DOE/CESER	Department of Energy Office of Cybersecurity, Energy Security, and Emergency Response
DOE/EERE	Department of Energy Office of Energy Efficiency and Renewable Energy
DOE/FE	Department of Energy Office of Fossil Energy
DOE/NE	Department of Energy Office of Nuclear Energy
DOE/NNSA	Department of Energy National Nuclear Security Administration
DOE/SC	Department of Energy Office of Science
DOI	Department of the Interior
DOJ	Department of Justice
DOL	Department of Labor
DOT	Department of Transportation
DREN	Defense Research and Engineering Network
ECP	Exascale Computing Project
ED	Department of Education
ED-IES	Department of Education Institute of Education Sciences
EdW	Education and Workforce
EHCS	Enabling R&D for High-Capability Computing Systems
ENIT	Electronics for Networking and Information Technology
EPA	Environmental Protection Agency

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Acronym	Definition
ERI	Electronics Resurgence Initiative
FAA	Federal Aviation Administration (DOT)
FAIR	Findability, Accessibility, Interoperability, and Reusability
FBI	Federal Bureau of Investigation
FCC	Federal Communications Commission
FCEN	Financial Crimes Enforcement Network (Treasury)
FDA	Food and Drug Administration
FFRDC	Federally Funded Research and Development Centers
FHIR	Fast Health Interoperability Resources
FHWA	Federal Highway Administration (DOT)
FMCSA	Federal Motor Carrier Safety Administration (DOT)
FTA	Federal Transit Administration (DOT)
FRA	Federal Railroad Administration (DOT)
FTC	Federal Trade Commission
GSA	General Services Administration
HBCU	Historically Black Colleges and Universities
HCC	High-Capability Computing
HCIA	High-Capability Computing Infrastructure and Applications
HEC	High End Computing
HHS	Department of Health and Human Services
HPC	High Performance Computing
HPCA	High Performance Computing Act of 1991
HPCMP	High Performance Computing Modernization Program
HRI	Human-Robot Interaction
HRSA	Health Resources and Services Administration
IARPA	Intelligence Advanced Research Projects Activity
IEEE	Institute of Electrical and Electronics Engineers
IIRD	Information Integrity R&D
IoT	Internet of Things
IRAS	Intelligent Robotics and Autonomous Systems
IT	Information Technology
ITA	International Trade Administration
IWG	Interagency Working Group
JET	Joint Engineering Team
JUMP	Joint University Microelectronics Program
LEAP	Leading Edge Acceleration Projects
LSDMA	Large-Scale Data Management and Analysis
LSN	Large Scale Networking
MAGIC	Middleware and Grid Interagency Coordination

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Acronym	Definition
MARAD	Maritime Administration
MDA	Missile Defense Agency
ML	Machine Learning
MLAI-SC	The Machine Learning and Artificial Intelligence Subcommittee
MSI	Minority-Serving Institution
NAII	National Artificial Intelligence Institute
NAIIA	National Artificial Intelligence Initiative Act of 2020
NAIIO	National Artificial Intelligence Initiative Office
NARA	National Archives and Records Administration
NASA	National Aeronautics and Space Administration
NASA/Aero	National Aeronautics and Space Administration Aeronautics Research Mission Directorate
NASA/Science	National Aeronautics and Space Administration Science Mission Directorate
NCATS	National Center for Advancing Translational Sciences (NIH)
NCCoE	National Cybersecurity Center of Excellence
NCI	National Cancer Institute
NCO	National Coordination Office
NEI	National Eye Institute (NIH)
NextG	Next Generation
NHTSA	National Highway Traffic Safety Administration
NICE	National Initiative for Cybersecurity Education
NIDILRR	National Institute on Disability, Independent Living, and Rehabilitation Research
NIFA	National Institute of Food and Agriculture (USDA)
NIH	National Institutes of Health
NIJ	National Institute of Justice
NIOSH	National Institute for Occupational Safety and Health
NIST	National Institute of Standards and Technology
NLP	Natural Language Processing
NITRD	Networking and Information Technology Research and Development Program
NMIO	National Maritime Intelligence-Integration Office
NOAA	National Oceanic and Atmospheric Administration
NOAA/ORF	National Oceanic and Atmospheric Administration Operations, Research and Facilities
NOAA/PAC	National Oceanic and Atmospheric Administration Procurement, Acquisition and Construction
NRC	Nuclear Regulatory Commission
NRL	Naval Research Laboratory
NRO	National Reconnaissance Office
NSA	National Security Agency
NSF	National Science Foundation
NSTC	National Science and Technology Council
NTIA	National Telecommunications and Information Administration

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Acronym	Definition
NTSB	National Transportation Safety Board
ODNI	Office of Director of National Intelligence
OMB	Office of Management and Budget
ONC	Office of the National Coordinator for Health Information Technology
ONR	Office of Naval Research
OSD	Office of the Secretary of Defense
OSHA	Occupational Safety & Health Administration
OSTP	Office of Science and Technology Policy
OT	Operational Technology
OUSD(R&E)	Office of the Under Secretary of Defense for Research and Engineering
PCA	Program Component Area
PCOR	Patient-Centered Outcomes Research
PSIAP	Public Safety Innovation Accelerator Program
PWD	Persons with Disabilities
QIS	Quantum Information Science
R&D	Research and Development
RADx	Rapid Acceleration of Diagnostics
RENEW	Reaching a New Energy Sciences Workforce
RF	Radio Frequency
RFI	Requests for Information
S&CC	Smart and Connected Communities
S&E	Science and Engineering
S&T	Science and Technology (or Science & Technology Directorate)
SAMHSA	Substance Abuse and Mental Health Services Administration
SARS-CoV-2	Severe Acute Respiratory Syndrome Coronavirus 2
SaTC	Secure and Trustworthy Cyberspace
SATCOM	Satellite Communications
SBIR	Small Business Innovation Research
SPSQ	Software Productivity, Sustainability, and Quality
SSA	Social Security Administration
State	Department of State
STEM	Science, Technology, Engineering, and Math
STRGP	Space Technology Research Grants Program
STTR	Small Business Technology Transfer
TILOS	AI Institute for Learning-Enabled Optimization at Scale
Treas	Department of Treasury
TRMC	Test Resource Management Center
UK	United Kingdom
USAGM	U.S. Agency for Global Media

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Acronym	Definition
USAID	U.S. Agency for International Development
USCYBERCOM	U.S. Cyber Command
USDA	U.S. Department of Agriculture
USBR	U.S. Bureau of Reclamation (DOI)
USGS	U.S. Geological Survey
USPTO	U.S. Patent and Trademark Office
USSF	U.S. Space Force
USTR	United States Trade Representative
VA	Department of Veterans Affairs
VIA	Video and Image Analytics
VR	Virtual Reality
WSRD	Wireless Spectrum R&D



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