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

SUPPLEMENT TO THE PRESIDENT'S FY 2023 BUDGET

A report by the
SUBCOMMITTEE ON NETWORKING AND INFORMATION TECHNOLOGY
RESEARCH AND DEVELOPMENT
and the
MACHINE LEARNING AND ARTIFICIAL INTELLIGENCE SUBCOMMITTEE

of the
NATIONAL SCIENCE AND TECHNOLOGY COUNCIL

November 2022

About the Office of Science and Technology Policy

The Office of Science and Technology Policy (OSTP) was established by the National Science and Technology Policy, Organization, and Priorities Act of 1976 to provide the President and others within the Executive Office of the President with advice on the scientific, engineering, and technological aspects of the economy, national security, health, foreign relations, and the environment, among other topics. OSTP leads interagency science and technology policy coordination efforts, assists the Office of Management and Budget with an annual review and analysis of Federal R&D in budgets, and serves as a source of scientific and technological analysis and judgment for the President with respect to major policies, plans, and programs of the Federal Government. More information is available at https://www.whitehouse.gov/ostp.

About the National Science and Technology Council

The National Science and Technology Council (NSTC) is the principal means by which the Executive Branch coordinates science and technology policy across the diverse entities that make up the Federal research and development (R&D) enterprise. A primary objective of the NSTC is to ensure science and technology policy decisions and programs are consistent with the President's stated goals. The NSTC prepares R&D strategies that are coordinated across Federal agencies aimed at accomplishing multiple national goals. The work of the NSTC is organized under committees that oversee subcommittees and working groups focused on different aspects of science and technology. More information is available at https://www.whitehouse.gov/ostp/nstc.

About the Subcommittee on Machine Learning and Artificial Intelligence

The Machine Learning and Artificial Intelligence (MLAI) Subcommittee monitors the state of the art in machine learning (ML) and artificial intelligence (AI) within the Federal Government, the private sector, and internationally to watch for the arrival of important technology milestones in the development of AI, to coordinate the use of and foster the sharing of knowledge and best practices about ML and AI by the Federal Government, and to consult in the development of Federal MLAI R&D priorities. The MLAI Subcommittee reports to the NSTC Committee on Technology and the Select Committee on AI.

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 2023 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 2021 actual, FY 2022 enacted, and FY 2023 requested funding levels by agency and Program Component Area for all NITRD R&D programs. It also describes the key R&D programs and coordination activities planned for FY 2023 by the Federal agencies participating in NITRD. This Supplement reports specific agency investments for FYs 2021–2023 for AI and the National AI Research Institutes and for advanced wireless communications. A separate appendix, the FY 2023 *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/FY2023-Cybersecurity-RD-Roadmap.pdf).

November 28, 2022

Dear Members of Congress:

I am pleased to share with you the Networking & Information Technology Research and Development (NITRD) Program and National Artificial Intelligence Initiative Office (NAIIO) Supplement to the President's FY 2023 Budget, and in a separate appendix, the FY 2023 Federal Cybersecurity R&D Strategic Plan Implementation Roadmap.

The NITRD Program, now in its 30th year, consists of 26 member agencies and more than 80 participating agencies. NITRD coordinates Federal research and development (R&D) investments in advanced technologies that are essential to the Nation's economic growth and prosperity.

This annual Supplement to the President's Budget provides a technical summary of NITRD members' budget investments and activities planned and coordinated through the NITRD Program from FY 2021 through FY 2023. The budget reporting and technical program summaries are organized by NITRD Program Component Area (PCA). As a requirement of the National AI Initiative Act of 2020, and in coordination with the NAIIO, the Supplement also reports specific agency investments for artificial intelligence (AI), including the National AI Research Institutes. The Supplement also reports on advanced wireless communications.

NITRD's budget crosscut has increased from $7.8 billion requested in FY 2022 to $9.6 billion requested in FY 2023. The $1.8 billion increase emphasizes the Biden Administration's commitment to robust, safe, secure, and privacy-preserving machine learning and to equity for all. Furthermore, R&D investments support the research, development, and application of technologies that promote socially responsible computing and defend critical infrastructure and sensitive networks.

The Biden-Harris Administration has emphasized the need for R&D investments to maximize the benefits of science and technology to advance health; tackle the climate crisis; and bring prosperity, security, environmental quality, and justice for all Americans. As the United States seeks to make supply chains stronger, continued investments in R&D, as well as in methods that benefit all individuals and all communities in America, are required to protect American security, to strengthen its economic resilience, and to create products that are made in the United States by U.S. workers. The collaborative nature of the NITRD Program continues to evolve and adapt to keep America on the cutting edge, creating a powerful intersection between technology and society where diversity can drive discovery and where technology can level the playing field for underserved and underrepresented communities.

I look forward to continuing to work with you to support the Administration's priorities, of which these vital Federal R&D programs are an important part.

Sincerely,

Arati Prabh

Dr. Arati Prabhakar
Director, Office of Science and Technology
Policy, Assistant to the President for Science and
Technology

NATIONAL SCIENCE AND TECHNOLOGY COUNCIL

Chair: Arati Prabhakar
Director, Office of Science and Technology Policy,
Assistant to the President for Science and Technology

Acting Executive Director: Kei Koizumi
Principal Deputy Director for Policy,
Office of Science and Technology Policy

Subcommittee on Networking and Information Technology Research and Development (NITRD)
Co-Chair: Margaret Martonosi, National Science Foundation (NSF)
Co-Chair: Kathleen (Kamie) Roberts, NITRD National Coordination Office (NCO)
Executive Secretary: Nekeia Butler, NCO

National Artificial Intelligence Initiative Office
Director: Dr. Arati Prabhakar, OSTP

National Coordination Office for Networking and Information Technology Research and Development
Director: Kathleen (Kamie) Roberts

NITRD Subcommittee Member Agencies and Representatives
(Principal representatives listed first)

Department of Commerce (DOC)
National Institute of Standards and Technology (NIST)
Charles H. Romine
Elham Tabassi

National Oceanic and Atmospheric Administration (NOAA)
Frank Indiviglio
Leslie Hart

Department of Defense (DoD)
Defense Advanced Research Projects Agency (DARPA)
Kathleen Fisher

Military Services

Air Force
Matthew D. Cocuzzi

Army
Jeffrey D. Singleton

Navy
Sandy Landsberg
Samuel Weber

National Security Agency (NSA)
Rita Bush
Shane Strutz

Office of the Secretary of Defense (OSD)
Kevin T. Geiss
Keith A. Krapels

Department of Energy (DOE)
Artificial Intelligence & Technology Office (DOE/AITO)
Jonnie Bradley

National Nuclear Security Administration (DOE/NNSA)
Thuc T. Hoang

DOE (continued)
Office of Cybersecurity, Energy Security, and Emergency Response (DOE/CESER)
Fowad Muneer

Office of Science (DOE/SC)
Barbara Helland

Department of Health and Human Services (HHS)
Agency for Healthcare Research and Quality (AHRQ)
Christine Dymek
Chun-Ju (Janey) Hsiao

National Institutes of Health (NIH)
Susan Gregurick
Laura Biven

National Institute for Occupational Safety and Health (NIOSH)
Frank Hearl
Vladimir Murashov

Office of the National Coordinator for Health Information Technology (ONC)
Steven Posnack
Stephen Konya

Department of Homeland Security (DHS)
Science & Technology Directorate (S&T)
Sridhar Kowdley
Russell Becker
John Vehmeyer

Department of the Interior (DOI)
U.S. Geological Survey (USGS)
Tim Quinn

Department of Justice (DOJ)
National Institute of Justice (NIJ)
Kyle Fox
Mark Greene

Department of State (State)
Office of S&T Cooperation
Scott L. Sellars

Department of Veterans Affairs (VA)
National AI Institute (NAII)
Gil Alterovitz

Food and Drug Administration (FDA)
Edward Margerrison
Dorn Carranza

National Aeronautics and Space Administration (NASA)
Kathleen B. Loftin
Bryan A. Biegel

National Archives and Records Administration (NARA)
Hung Nguyen

National Reconnaissance Office (NRO)
Thomas Jenkins

National Science Foundation (NSF)
Margaret Martonosi
Joydip Kundu

Executive Office of the President
Office of Management and Budget (OMB)
Avital Bar-Shalom
Liuyi Pei

Office of Science and Technology Policy (OSTP)
Kei Koizumi

OTHER PARTICIPATING DEPARTMENTS AND AGENCIES

These Federal departments and agencies participate in NITRD activities and have mission interests in advanced networking and IT R&D and applications, but they are not members of the NITRD Subcommittee.

Department of Agriculture (USDA)
Agricultural Research Service (ARS)

Agriculture and Food Research Initiative (AFRI)

National Institute of Food and Agriculture (NIFA)

Department of Commerce (DOC)
International Trade Administration (ITA)

National Telecommunications and Information Administration (NTIA)

United States Census Bureau (Census)

U.S. Patent and Trademark Office (USPTO)

Department of Defense (DoD)
Defense Health Agency (DHA)

Defense Research and Engineering Network (DREN)

Joint Artificial Intelligence Center (JAIC)

Military Services Facilities:

Air Force Office of Scientific Research (AFOSR)

Army Research Laboratory (ARL)

Combat Capabilities Development Command (Army–CCDC)

Command, Control, Communication, Computers, Cyber, Intelligence, Surveillance and Reconnaissance Center (Army–C5ISR)

C5ISR Space and Terrestrial Communications Directorate (C5ISR S&TCD)

Naval Research Laboratory (NRL)

U.S. Army Medical Research and Development Command (USAMRDC)

Office of the Under Secretary of Defense for Research and Engineering (OUSD (R&E))

Test Resource Management Center (TRMC)

DoD (continued)
U.S. Army Corps of Engineers (USACE)

U.S. Cyber Command (USCYBERCOM)

Department of Energy (DOE)
Advanced Research Projects Agency–Energy (ARPA-E)

Office of Energy Efficiency and Renewable Energy (EERE)

Office of Electricity (OE)

Office of Fossil Energy (FE)

Office of Nuclear Energy (NE)

Department of Health and Human Services (HHS)
Administration for Community Living (ACL)

Centers for Disease Control and Prevention (CDC)

Centers for Medicare & Medicaid Services (CMS)

Food and Drug Administration (FDA)

Health Resources and Services Administration (HRSA)

Indian Health Service (IHS)

National Cancer Institute (NCI)

National Center for Health Statistics (NCHS)

Substance Abuse and Mental Health Services Administration (SAMHSA)

Department of Homeland Security
Cybersecurity and Infrastructure Security Agency (CISA)

Department of Justice (DOJ)
Drug Enforcement Administration (DEA)

Federal Bureau of Investigation (FBI)

Department of Labor (DOL)
Bureau of Labor Statistics (BLS)

Occupational Safety & Health Administration (OSHA)

Department of Transportation (DOT)
Federal Aviation Administration (FAA)

Federal Highway Administration (FHWA)

Federal Motor Carrier Safety Administration (FMCSA)

Federal Railroad Administration (FRA)

Federal Transit Administration (FTA)

Intelligent Transportation Systems Joint Program Office (ITS JPO)

Maritime Administration (MARAD)

National Highway Traffic Safety Administration (NHTSA)

Pipeline and Hazardous Materials Safety Administration (PHMSA)

Department of the Treasury (Treasury)
Financial Crimes Enforcement Network (FinCEN)

Environmental Protection Agency (EPA)

Federal Communications Commission (FCC)

Federal Trade Commission (FTC)

General Services Administration (GSA)

Intelligence Community
Intelligence Advanced Research Projects Activity (IARPA)

National Maritime Intelligence-Integration Office (NMIO)

Office of Director of National Intelligence (ODNI)

National Transportation Safety Board (NTSB)

Nuclear Regulatory Commission (NRC)

Social Security Administration (SSA)

Table of Contents

List of Figures

List of Tables

1.0 Introduction

The Networking and Information Technology Research and Development (NITRD) Program is the Nation's primary source of federally funded R&D in advanced IT for computing, networking, and software. NITRD is among the oldest and largest of formal Federal programs that coordinate the activities of multiple agencies to tackle multidisciplinary, multi-technology, and multisector R&D needs, such as within artificial intelligence (AI), high-performance computing (HPC), robotics, quantum information science (QIS), cybersecurity, advanced communications technology, big data, and digital health. The NITRD agencies now invest approximately $9.6 billion annually in R&D programs that identify, develop, and transition to practical use the advanced networking and IT capabilities needed by the Federal Government and the Nation.

Advanced networking and IT capabilities underpin U.S. technological leadership in the world, as well as American military superiority, national security, economic prosperity, energy independence, climate change, health equity, and expansion of the skilled cyber-enabled workforce. 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. The NITRD collaboration framework also supports individual and joint agency outreach to academia and industry to foster alliances, provide a cutting-edge IT research infrastructure, and strengthen the national innovation ecosystem.

R&D is critical to the development of technologies that will launch the Nation into the next computing revolution and ensures that these advances support national priorities such as the Nation's economic competitiveness, security, well-being, response to climate change, and leadership in science and engineering. As such, the NITRD Program's impact on agency R&D collaboration has been crucial in providing agencies a platform to work together and with public and private entities by performing activities including, but not limited to, the following:

- Identifying R&D priorities for government, academia, and the private sector.
  - For example, the company DeepMind purchased physics modeling and simulation package MuJoCo after a joint NITRD agency workshop concluded that advances in modeling and simulation are needed for robotics to advance. Based on the results published in the *Proceedings of the National Academy of Sciences*,[1] DeepMind purchased MuJoCo and made it freely available.[2]
- Providing smaller R&D agencies with access to experts to leverage common R&D gaps.
  - AI R&D Interagency Working Group (IWG) workshops on common R&D objectives and privacy framework offer opportunities for smaller agencies to gain insight from larger R&D agencies.
- Highlighting key R&D priorities that are developed into research agendas by academia.
  - NITRD-sponsored workshops on Assured Autonomy impact research activities at NSF, NIST, NASA, and NSA. These activities are incorporated into academic research agendas.

---

[1] https://www.pnas.org/doi/10.1073/pnas.1907856118
[2] https://www.deepmind.com/blog/opening-up-a-physics-simulator-for-robotics

- Connecting agencies to resolve joint R&D gaps.
  - NSF AI Institute for Edge Computing Leveraging Next Generation Networks – Athena. The AI Research Institute is funded by NSF and DHS. For more information, see Section 5.2.1.1.
- Forming partnerships to address and support science, technology, engineering, and mathematics (STEM) education and workforce development needs.
  - DARPA's Joint University Microelectronics Program funds six microelectronics research centers spanning 31 universities involving over 800 graduate students performing fundamental electronics research across over 240 projects.
- Expanding agency involvement in joint R&D priorities.
  - Five High End Computing Interagency Working Group (HEC IWG) agency members have joined the DOE Exascale Computing Project (ECP) Industry and Agency Committee. Various HEC agencies have participated in past ECP workshops.
- Informing government leaders and policymakers.
  - The NITRD Program reports and highlights advances in networking and information technologies through a variety of methods. For example, this Supplement, published jointly with the National AI Initiative Office (NAIIO), reports funding and research focus areas for the National AI Research Institutes.

> **Multi-Agency R&D Priorities**
> "...to refresh and reinvigorate our Nation's science and technology enterprise with the aim of harnessing the full power of science and technology on behalf of the American people."
> - Pandemic readiness and prevention
> - Tackling climate change:
>   - Climate science
>   - Innovation in clean-energy technologies and infrastructure
>   - Climate adaptation and resilience
> - Nature-based climate solutions for mitigation and adaptation
> - Monitoring and measurement
> - Research and innovation in critical and emerging technologies
> - Innovation for equity
> - National security and economic resilience
>
> **Require Continued Investments**
> - Continued investments in R&D
> - Science, technology, engineering, and mathematics (STEM) education and engagement
> - STEM workforce development
> - Technology transfer and commercialization
> - Research infrastructure, with emphasis on HBCUs, other minority serving Institutions, and disadvantaged communities who have been historically underserved, marginalized, and adversely affected by persistent poverty and inequality
>
> from *Multi-Agency Research and Development Priorities for the FY 2023 Budget,* M-21-32, August 27, 2021

1.1 History

With the High Performance Computing Act of 1991, Congress launched what is now called the NITRD Program. Congress has reauthorized and expanded the NITRD Program three times, most recently in the 2017 American Innovation and Competitiveness Act.[3] NITRD marked 30 years of innovation and collaboration during fiscal year (FY) 2022.[4,5]

---

[3] https://www.congress.gov/114/plaws/publ329/PLAW-114publ329.pdf; https://www.nitrd.gov/legislation/
[4] Please see the NITRD 30th Anniversary video at https://www.youtube.com/embed/H943la5Lx-A
[5] For more information, please visit the NITRD 30th Anniversary Symposium page at https://www.nitrd.gov/30th-anniversary-of-the-nitrd-program/

The NITRD Program has grown from the founding 8 member agencies to 26 NITRD member agencies, along with OSTP, NSTC, and OMB, that today make up the NSTC's NITRD Subcommittee, which oversees the NITRD Program with operational assistance from the NITRD National Coordination Office (NCO). The President's Council of Advisors on Science and Technology independently reviews the NITRD Program at least every three years.

1.2   Purpose

This report meets NITRD's obligation to submit a Supplement to the President's Budget to Congress annually. In this report, member agencies describe their R&D budget requests, as well as their programs and activities for the coming fiscal year in HPC, IT, and networking. The report also addresses how the NITRD Program members and participants plan to support the S&T priorities of the President and of OSTP (see sidebar on previous page).

Following enactment of the National Artificial Intelligence Initiative Act (NAIIA) of 2020 and establishment of the National Artificial Intelligence Initiative Office (NAIIO), this Supplement also meets NAIIO's obligation to submit NAIIA-related budget and program information to Congress as part of the President's annual budget request. As specified in the Act, the tables in Section 2.0 include a summarized budget in support of the National AI Initiative for the preceding, current, and proposed fiscal years, and a breakdown of spending for the National AI Research Institutes.

1.3   NITRD Program Component Areas

NITRD's annual budget is organized by Program Component Area (PCA) and agency to facilitate year-to-year budgetary and programmatic trend analysis. The PCAs are categories of technical R&D focus supported by NITRD member agency investments. PCAs are the major subject areas under which Federal agencies report their funding requests for the NITRD-related activities. The NITRD PCAs are reviewed annually to ensure that the NITRD Program actively addresses evolving IT R&D and policy needs. For FY 2023, the Subcommittee performed a comprehensive review of the PCA definitions. Major updates include the renaming of Large Scale Networking to Advanced Communication Networks and Systems, and updates to the definitions of most PCAs. The NITRD web page provides information on each fiscal year's PCA definitions.[6] Following are the FY 2023 NITRD PCAs:

- Advanced Communication Networks and Systems (ACNS)
- Advanced Wireless R&D (AWRD) (ACNS 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)

---

[6] https://www.nitrd.gov/program-component-areas/

1.4   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 1.4-1 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 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. For FY 2023, the Health Information Technology R&D IWG has been renamed to Digital Health R&D (DHRD) to better reflect the evolving R&D landscape of health technologies. Additionally, NITRD is reporting the activities of the Information Integrity R&D (IIRD) IWG established in August 2021. Following are the FY 2023 NITRD IWGs and subgroups.

- Artificial Intelligence R&D (AI)
  - 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)

- Large Scale Networking (LSN)
  - 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)

Figure 1.4-1 shows the relationships of the IWGs to the PCAs in which their investments are reported.
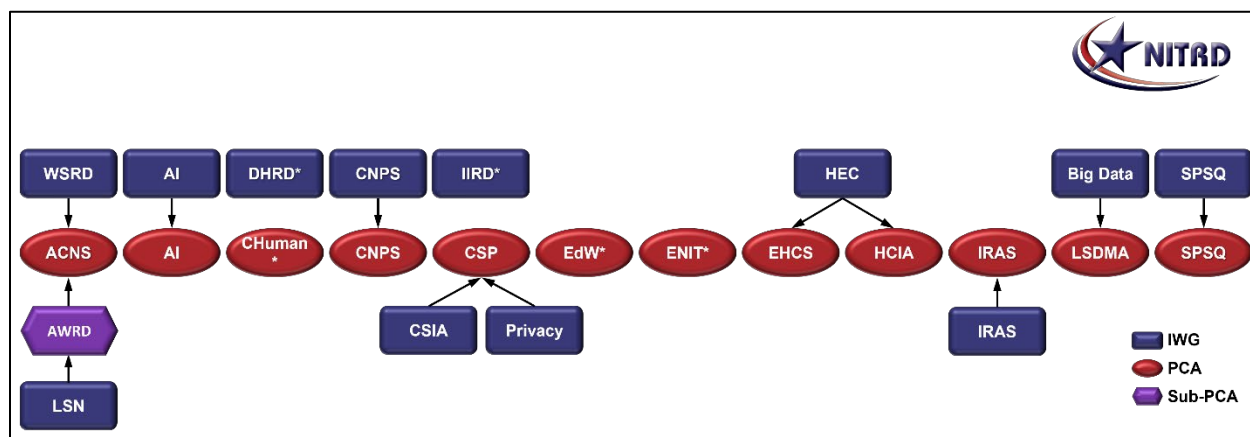
Figure 1.4-1. Relationships Between the NITRD IWGs and PCAs for FY 2023

Notes: The DHRD (formerly HITRD) 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.

1.4.1 NITRD IWG Roles in Furthering Public-Private R&D Partnerships

The IWGs work throughout the year to promote public-private engagement and partnerships by performing the following activities:

- Host and report on cross-community and cross-sector technical workshops.
- Present and hold meetings at national and international technical symposiums such as the International Conference for High Performance Computing, Networking, Storage, and Analysis.
- Compile, publish, and update nitrd.gov resource guides and inventories of Federal R&D programs for public use:
  - AI R&D Testbed Inventory
  - AI Research Program Repository
  - Broadband Resource Guide
  - Federal High End Computing Information Portal
  - Federal Smart Cities & Communities Programs Resource Guide
  - Science, Technology, Engineering, and Mathematics (STEM) Portal
- Review and update R&D strategic plans, as mandated by Congress or as IWG agency members and participants determine there is a need; these plans serve as guides for not only the Federal IT R&D community but also the academic and industrial IT R&D communities.

1.4.2 NITRD IWG Coordination with NSTC S&T Committees

NITRD's interdisciplinary R&D agenda creates natural synergies between its IWG efforts and other efforts of the NSTC enterprise, including those of the Committees and Subcommittees listed in Figure 1.4-2.
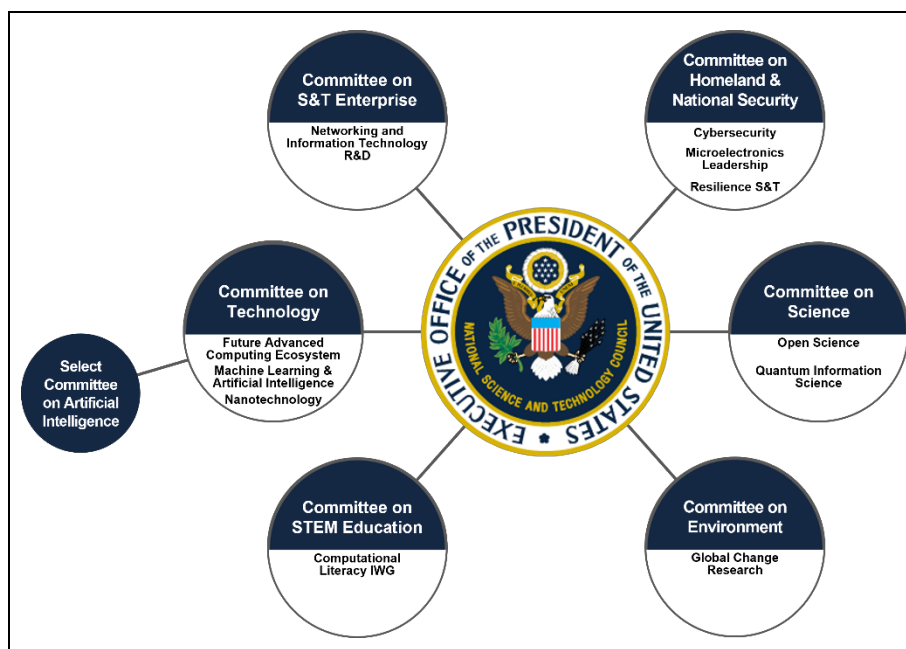
Figure 1.4-2. Collaborations with Other NSTC S&T Committees and Subcommittees

For FY 2023, the NITRD Program anticipates greater involvement with many of the NSTC S&T Subcommittees, and greater focus on data and equity issues in creation and delivery of digital services. NITRD is making a concerted effort to identify synergies and pursue collaborations with several NSTC Subcommittees, such as the Future Advanced Computing Ecosystem (FACE) Subcommittee, the Subcommittee on Open Science, and the NAIIO, to advance research on the technical foundations of a National Research Ecosystem to establish integrated data, compute, software, and education resources for the AI and Science and Engineering Communities, and to provide an open data forum.

In addition, NITRD is working with the FACE Subcommittee and the Subcommittee on Resilience S&T to develop the concept of the National Strategic Computing Reserve (NSCR).[9] The NSCR is envisioned as a coalition of resource providers (of compute, software, and data) and technical experts spanning government, academia, nonprofits/foundations, industry, civil society, and communities of practice that can be mobilized quickly to provide critical cyberinfrastructure capabilities and services in times of urgent need.

> **Coordinating Biden-Harris Administration Priorities[7]**
>
> The CHIPS and Science Act of 2022 [8] provides funding to restore U.S. leadership in semiconductor manufacturing, a crucial element of the networking and IT ecosystem. The NITRD Subcommittee is coordinating semiconductor R&D efforts with the NSTC Subcommittee on Microelectronics Leadership, and the other National Coordination Offices. Additional information about how the NITRD Program is assisting with the Administration's efforts is available in Section 3.7.

---

[7] https://www.whitehouse.gov/ostp/news-updates/2022/09/19/the-biden-harris-administration-begins-implementation-of-chips-and-science-act-to-benefit-american-communities/
[8] https://science.house.gov/chipsandscienceact
[9] https://www.nitrd.gov/national-strategic-computing-reserve-blueprint/

As required by the NAIIA, the NAIIO, NITRD, and the Machine Learning and Artificial Intelligence Subcommittee are collaborating on the update to the *National Artificial Intelligence Research and Development Strategic Plan: 2019 Update.* [10] The agencies are also developing a document to report agency progress toward meeting the goals of the 2019 AI strategic plan. The NAIIO and NITRD are collaborating on maintaining an AI Researchers Portal that connects AI researchers to the multitude of Federal resources available to them. This collaboration includes the following:

- AI Research Program Repository, [11] which went live in February 2022, 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 Inventory, [12] for researchers to locate Federally supported testbed and testing resources needed for their research.
- Data [13] and Computing [14] Resources for access to resources available through Federal programs.

NITRD places great importance on furthering STEM activities with its member and participating agencies, and is working closely with the Committee on STEM, Computational Literacy IWG, to advance, strengthen, and build computational literacy in STEM education.

To further highlight STEM opportunities for students in K–12, community colleges, undergraduate and graduate institutions, postdoctoral fellows, early career researchers, and K–12 educators, NITRD has developed the STEM Portal, [15] which provides information on internships, fellowships, scholarships, and other training programs. Additionally, NITRD is reaching out to Minority Serving Institutions (MSIs) to ensure awareness of STEM opportunities, with an overall objective of increasing collaboration between the Federal Government and MSIs.

Similarly, the NAIIO promotes agencies' graduate and postdoctoral fellowships and scholarship programs [16] to ensure that highly skilled experts are available to advance future AI technologies.

1.5   Structure of This Supplement

This document contains five main sections and one appendix. Following is the list, not including this section:

- Section 2.0 provides budget data for Federal R&D investments made in FY 2021 and enacted in FY 2022 (as well as supplementals), and requests for the President's FY 2023 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.

---

[10]   https://www.nitrd.gov/pubs/National-AI-RD-Strategy-2019.pdf
[11]   https://www.nitrd.gov/apps/ai-research-program-repository/
[12]   https://www.nitrd.gov/apps/ai-rd-testbed-inventory/
[13]   https://www.ai.gov/ai-researchers-portal/data-resources/
[14]   https://www.ai.gov/ai-researchers-portal/COMPUTING-RESOURCES/
[15]   https://www.nitrd.gov/stem4all/
[16]   https://www.ai.gov/strategic-pillars/education-and-training/

- [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](#) lists and describes the National AI Research Institutes.
- [Appendix A](#) contains the list of abbreviations and acronyms used in this document, as well as the related meaning.

1.6 NITRD Responses to the OSTP/OMB Listed Priorities [17]

The Administration's priorities for the FY 2023 R&D budget were presented in the memorandum issued on August 27, 2021, by OSTP and OMB. [Table 1.6-1](#) provides descriptions of selected agencies' investments related to the listed priorities.

Table 1.6-1. Agency Investments in Administration Priorities

Programs Related to Priorities	Program Descriptions/Goals	Agencies Involved
Pandemic Readiness and Prevention		
Biopreparedness Research Virtual Environment	Framework to rapidly activate, integrate, and coordinate the expertise and research capabilities, including exascale computing, across the DOE Lab Complex to address urgent research needs in an emerging crisis (*data and technology investments*).	DOE/SC
COVID-19 Open Research Dataset (CORD-19)	Free resource of more than 280,000 scholarly articles about the novel coronavirus for use by the global research community (*data infrastructure*).	NLM, OSTP, industry partners
Predictive Intelligence for Pandemic Prevention	Initiative that focuses on fundamental research and capabilities needed to tackle grand challenges in infectious disease pandemics through prediction and prevention (*data and technology investments*).	NSF
Rapid Acceleration of Diagnostics (RADx®) programs	**RADx Radical (RADx-rad)**: Program to advance diagnostic technologies through use of AI for screening, diagnosing, and monitoring COVID-19. **RADx Tech**: Program to speed the development, validation, and commercialization of innovative point-of-care and home-based tests. **RADx Underserved Populations (RADx-UP)**: Program to lay the foundation to reduce disparities in populations disproportionately affected by the COVID-19 pandemic (*early warning*).	BARDA, CDC, FDA, NIH
The Role of Telehealth in COVID-19 Response	Research to examine the impact of the COVID-19 pandemic and telehealth on utilization, outcomes, disparities, and public health surveillance (*data and technology investment*).	AHRQ
Smart and Connected Health	Joint NSF-NIH initiative seeking to accelerate development and use of next-generation healthcare solutions by funding high-risk, high-reward efforts in areas such as information science, technology, behavior, cognition, sensors, robotics, bioimaging, and engineering (*vaccine development and manufacturing*).	NIH, NSF
Tackling Climate Change		
Digital Twins	Technology to provide a virtual representation of the real ocean that combines data and observations from the real ocean with models, data science and artificial intelligence to adapt as the real world changes (*increasing adaptation and resilience, including through integration of physical, natural, and social sciences*).	NOAA

---

[17] Memorandum for the Heads of Executive Departments and Agencies, *Multi-Agency Research and Development Priorities for the FY 2023 Budget*, https://www.whitehouse.gov/wp-content/uploads/2021/08/FY23-Multi-Agency-RD-Budget-Priorities-Memo.pdf

Programs Related to Priorities	Program Descriptions/Goals	Agencies Involved
Extension, Education, and USDA Climate Hub Partnerships	Partnerships that train the next generation of agriculturalists and foresters to incorporate climate change research into their management practices (*investments that advance understanding of climate change*).	USDA-NIFA
Integrated Computational and Data Infrastructure (ICDI)	Effort to prevent coastal flooding through the use of digital twin techniques (*increasing adaptation and resilience, including through integration of physical, natural, and social sciences*).	DOE/SC
National Discovery Cloud for Climate	A resource federating advanced computation, data, software, and networking to democratize access to cyberinfrastructure furthering climate science (*investments that advance understanding of climate change*).	NSF
NSF AI Institute for Research on Trustworthy AI in Weather, Climate, and Coastal Oceanography	This National AI Research Institute's goal is to create trustworthy AI methods for diverse environmental science users that will revolutionize understanding and prediction of high-impact atmospheric and ocean science phenomena and create new educational pathways to develop a more diverse AI and environmental science workforce (*advance understanding of societal and economic impacts*).	NOAA, NSF
Research and Innovation Impetus in Critical and Emerging Technologies		
Many of the efforts listed in Sections 3.0 and 4.0 align with this priority; following are just a few examples.		
Artificial Intelligence/Machine Learning Consortium to Advance Health Equity and Researcher Diversity (AIM-AHEAD)	Program to establish mutually beneficial and coordinated partnerships to increase the participation and representation of researchers and communities currently underrepresented in the development of artificial intelligence/machine learning (AI/ML) models and enhance the capabilities of this emerging technology, beginning with electronic health record data (*public-private partnerships, prioritize fundamental and translational AI research*).	NIH
Bridge to Artificial Intelligence (Bridge2AI)	Program to generate new flagship biomedical and behavioral datasets, develops new AI software and standards, and trains new researchers in field of biomedical AI.	NIH
CHIPS and Science Act of 2022	Surges production of American-made semiconductors, tackles supply chain vulnerabilities to make more goods in America, revitalizes America's scientific research and technological leadership, and strengthens America's economic and national security at home and abroad (*innovation for equity, national security and economic resilience, public-private partnerships*).	DOC, DOE/SC, NASA, NIST, NSF
Foundational Research in Robotics	Supports research on robotic systems that exhibit significant levels of both computational capability and physical complexity. Research considers inextricably interwoven questions of intelligence, computation, and embodiment (*prioritize fundamental and translational AI research, grow our inclusive 21st-century digital economy*).	NSF
Harnessing the Data Revolution	Enables new models of data-driven discovery that will address fundamental questions at the frontiers of science and engineering. Pursues research in data science and engineering; the development of a cohesive, federated, national-scale approach to research data infrastructure; and the development of a 21st-century, data-capable workforce (*prioritize fundamental and translational AI research, grow our inclusive 21st-century digital economy*).	NSF

Programs Related to Priorities	Program Descriptions/Goals	Agencies Involved
National Research Council Research Associateship Program	Program that provides postdoctoral candidates the opportunity to spend 2–3 years working on leading-edge transportation research in world-class facilities with top-notch experts. Research associates are matched with an FHWA adviser who mentors them throughout the program (*prioritize fundamental and translational AI research*).	DOT, NIST
Resilient and Intelligent NextG Systems	Lays the groundwork for next-generation wireless connections that will enable faster service; resiliency to natural disasters, malicious attacks, and service interruptions; and broader access to wireless connectivity for people across the United States (*innovation for equity, national security and economic resilience, prioritize fundamental and translational AI research*).	DoD, NIST, NSF
Trojans in Artificial Intelligence	Program to combat Trojan attacks by inspecting AIs for Trojans (*grow our inclusive 21st-century digital economy*).	IARPA, NIST
Innovation for Equity		
Developing solutions for minimizing privacy risks while maximizing the utility of data analytics is a major objective for agency investments in privacy research. Census Bureau, NIH, NIST, NSA, and NSF are developing practical approaches for implementing privacy protections in data analytics systems, for example, to provide privacy-preserving access to precision health data.		
All of Us Research Program	Program to establish a one-million volunteer participant group reflecting the Nation's genealogical and health diversity to contribute health data to leverage technology advances in genomics, computing, and data analytics, and to capitalize on mobile health technology. People of every race, ethnicity, sex, gender, and sexual orientation are welcome (*focus on underutilized, inaccessible, or missing data*).	NIH, academic/ public/private/ industry partners
Computer and Information Science and Engineering (CISE) Minority-Serving Institutions Research Expansion Program	Program to broaden participation by increasing the number of CISE-funded research projects from MSIs and develop research capacity toward successful submissions to core CISE programs (*improve diversity and equity in the research workforce*).	NSF
EarthCube	Community-driven activity sponsored by NSF to transform research in the academic geosciences community. One outcome goal is the development of a diverse, globally competitive STEM workforce (*improve diversity and equity in the research workforce*).	NSF
Women in IT Networking at SC	Developed as a means for addressing the prevalent gender gap that exists in IT, particularly in the fields of network engineering and high-performance computing (*improve diversity and equity in the research workforce, develop data infrastructure that facilitates identification of inequities*).	DOE/SC, NSF
National Security and Economic Resilience		
National security objectives are advanced by a significant portfolio of cybersecurity research programs and investments. Federal agencies pursue basic scientific as well as applied research in cybersecurity to achieve deterrence, detection of and protection against cyber threats, sustainment of critical functions, and to increase resilience against cyber attacks. The accompanying *FY 2023 Federal Cybersecurity R&D Strategic Plan Implementation Roadmap* provides a listing of the major programs and investments.		
Computational Modeling and Analysis	Program of research that advances computational modeling and analysis methods for aerospace propulsion components and systems (*reduction of catastrophic biological, nuclear, and cyber risks*).	NASA

Programs Related to Priorities	Program Descriptions/Goals	Agencies Involved
Computational Research and Engineering Acquisition Tools and Environments program	Portfolio of investments for development, deployment, and maintenance of software applications in response to critical capability requirements of the DoD acquisition community that was established to meet the challenge of significantly reducing acquisition time, risk, and cost, while increasing weapon system agility, flexibility, and performance (*research, development, and application of technologies that protect American security*).	DoD
Future of Work at the Human Technology Frontier: Core Research	Research to sustain economic competitiveness; promote worker well-being, lifelong and pervasive learning, and quality of life; and illuminate the emerging social and economic context and drivers of innovations that are shaping the future of jobs and work (*research, development, and application of technologies that strengthen our economic resilience*).	NSF
Scientific Discovery through Advanced Computing partnerships	Program to develop the Scientific Computing Software and Hardware Infrastructure needed to advance scientific discovery using supercomputers (*defending critical infrastructure and sensitive networks against cyberattacks and supply chain attacks*).	DOE/SC
Secure and Trustworthy Cyberspace	Protect and preserve the growing social and economic benefits of cyber systems while ensuring security and privacy (*reduction of catastrophic biological, nuclear, and cyber risks*).	NSF
STEM Education and Engagement Guidance		
Computational Science Graduate Fellowship Program	Program to provide outstanding benefits and opportunities to students pursuing doctoral degrees in fields that use high-performance computing to solve complex science and engineering problems (*enhance instructional, organizational, and institutional environments for STEM learning*).	DOE/NNSA, DOE/SC
NSF Research Traineeship program	Develop ways for graduate students in research-based master's and doctoral degree programs to develop the skills, knowledge, and competencies needed to pursue a range of STEM careers (*training and talent development for our future STEM workforce*).	NSF

Meeting the Biden-Harris Administration's Top Priorities

Another critical priority for the Biden-Harris Administration is the Cancer Moonshot[SM] Initiative. [18] This initiative has the goal of reducing the cancer death rate by half over the next 25 years through the development and deployment of new ways to prevent, detect, and treat cancer. [19]

The National Library of Medicine's ClinicalTrials.gov [20] provides an online database of clinical research studies and information about the results of clinical trials, including those related to cancer. This information is available to the public, researchers, and healthcare professionals. Additionally, the NIH funds clinical trials dedicated to improving cancer-related care and outcomes across the cancer control continuum at the Centers on Telehealth Research for Cancer-Related Care. For more information on the Centers efforts, please see Section 4.1.

The National Cancer Initiative (NCI) and Department of Energy are collaborating on the Joint Design of Advanced Computing Solutions for Cancer [21] to accelerate cancer research using emerging exascale computing capabilities (capable of a billion calculations per second). Announced as part of the Cancer Moonshot, it is an innovative cross-agency collaboration designed to equally benefit NCI and the Department of Energy (DOE). See Section 3.9 for more information on the collaboration.

---

18   https://healthcaredelivery.cancer.gov/telehealth/trace.html
19   https://www.whitehouse.gov/cancermoonshot/
20   https://www.cancer.gov/research/key-initiatives/moonshot-cancer-initiative; https://beta.clinicaltrials.gov/study/NCT04314401
21   https://datascience.cancer.gov/collaborations/joint-design-advanced-computing

2.0 Agency NITRD- and NAIIO-Related R&D Investments, FY 2021–FY 2023

This section reports NITRD R&D budgets by PCA and agency, including overall Federal IT-related R&D investments (Table 2.1-1) and R&D investments in three high-priority areas: Artificial Intelligence R&D (Table 2.1-2), the National Artificial Intelligence Institutes (Table 2.1-3), and Advanced Wireless Networks (AWN) R&D (Table 2.1-4). Tables 2.1-1 through 2.1-4 provide agencies' FY 2021 actual and supplemental R&D investments, FY 2022 enacted and supplemental budgets, and FY 2023 budget requests. Section 2.2 describes changes of investment greater than $10 million, by agency, between the FY 2022 enacted budgets and the FY 2023 President's Budget Request. Additional NITRD R&D investment information for FY 2002–FY 2023 is available at https://www.nitrd.gov/apps/itdashboard/dashboard/.

2.1 Budget Charts

Figure 2.1-1 shows the FY 2023 Budget Request by PCA (a) and agency (b).

a. FY 2023 Budget Request, in millions,
of the total NITRD request, by PCA
See Appendix A for spell-outs of PCA and agency acronyms.

b. FY 2023 Budget Request, in millions,
of the total NITRD request, by agency
Other: AHRQ, DHS, DOE/NNSA, DOI, DOT, EPA, FDA,
NARA, NASA, NIJ, NIOSH, NOAA, NTIA, USDA, VA
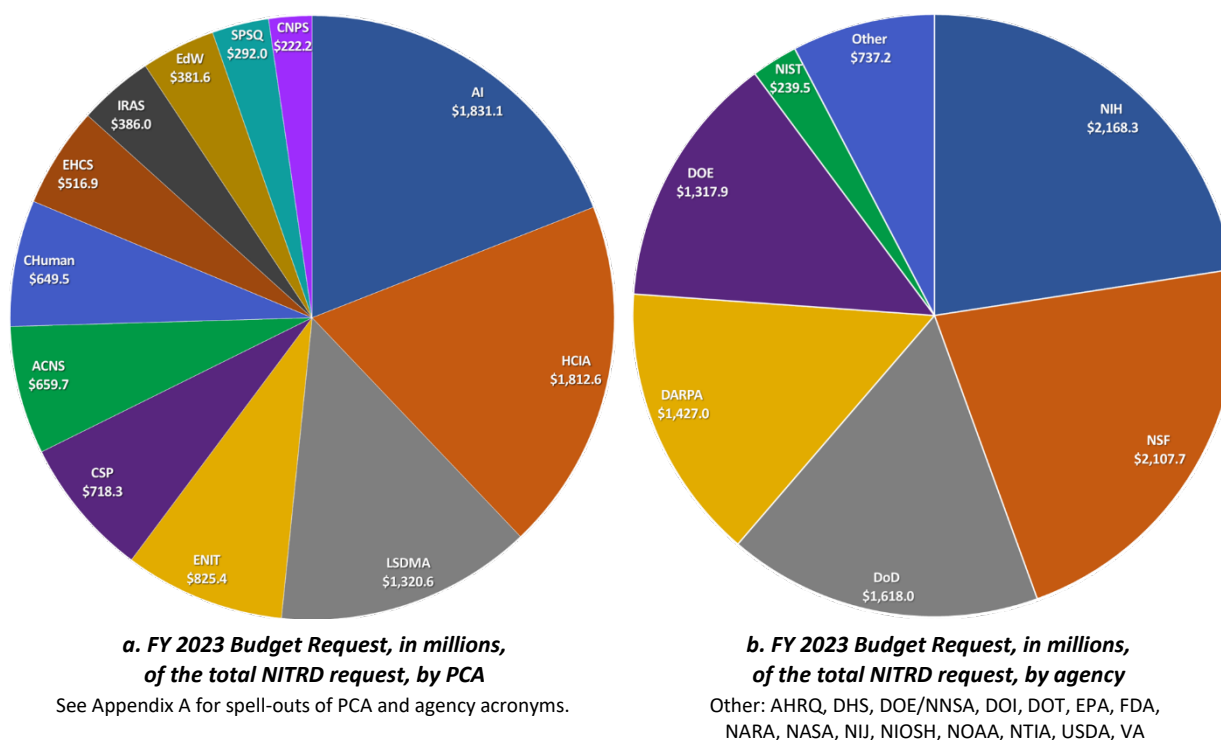
Figure 2.1-1. FY 2023 Budget Request as Percentages of the Total NITRD Request

2.1.1 Agency Budgets by NITRD PCA

As depicted in Table 2.1-1, the President's overall FY 2023 budget request for Federal agencies' NITRD-related R&D is $9.6 billion—an increase of approximately 23.1 percent compared to the $7.8 billion originally requested for FY 2022.[22] The increase of $1.8 billion is a result of DoD (including DARPA) reporting numbers in AI for this reporting cycle. Additionally, DARPA reported numbers in ENIT this cycle that were not reported in the last cycle.

Note: For the FY column, FY 2021 refers to actual budget, FY 2022 refers to enacted budget, and FY 2023 refers to budget request. Fiscal years with "-S" after them denote supplemental funding.

Table 2.1-1. Agency Budgets by NITRD PCA, FYs 2021–2023

Agency	FY	12 NITRD Program Component Areas												Totals
		ACNS	AI	CHuman	CNPS	CSP	EdW	ENIT	EHCS	HCIA	IRAS	LSDMA	SPSQ	
AHRQ	2021	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
	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	18.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.3
DARPA	2021	43.8	412.0	0.0	0.0	240.1	0.0	327.8	5.1	0.0	0.0	30.2	0.0	1,058.9
	2022	53.5	456.7	0.0	0.0	252.1	0.0	410.5	5.1	0.0	0.0	26.9	0.0	1,204.8
	2023	76.7	412.4	0.0	0.0	183.8	0.0	708.7	5.1	0.0	0.0	40.3	0.0	1,427.0
DHS	2021	14.5	37.7	0.0	6.5	25.8	1.5	0.1	0.0	0.0	1.5	1.3	0.0	88.9
	2022	7.0	41.2	0.0	8.0	54.3	2.2	4.1	0.0	0.0	0.4	7.8	0.0	125.0
	2023	7.3	38.5	0.0	17.0	49.1	1.0	4.0	0.0	0.0	0.0	3.7	0.0	120.6
DoD	2021	173.6	105.0	176.4	26.2	244.7	78.2	7.7	51.0	268.2	121.4	187.6	62.1	1,502.1
	2021-S	25.7	0.0	5.0	0.0	9.9	0.0	0.0	9.9	0.0	0.0	4.9	0.0	55.4
	2022	123.2	203.3	163.4	16.2	165.7	138.2	11.3	44.5	196.6	229.9	194.5	44.6	1,531.4
	2022-S	27.0	0.0	3.8	0.0	3.2	0.0	0.0	35.0	0.0	4.8	5.0	0.0	78.8
	2023	126.1	241.5	170.3	15.1	173.2	125.5	8.5	42.9	259.5	245.9	193.9	15.7	1,618.0
DOE	2021	88.0	153.5	0.0	10.0	9.0	35.7	0.0	112.1	645.4	7.4	3.8	0.0	1,064.9
	2022	90.0	118.4	0.0	6.0	19.6	35.9	0.0	146.6	705.5	5.8	0.0	0.0	1,127.8
	2023	95.2	148.3	0.0	5.0	72.5	57.0	0.0	168.9	764.3	1.7	5.0	0.0	1,317.9
DOE/ NNSA	2021	0.8	29.9	0.0	0.0	0.4	0.0	0.0	6.0	0.0	0.0	0.0	0.0	37.1
	2022	1.6	29.6	0.0	0.0	0.7	0.0	0.0	24.0	0.0	0.0	0.0	0.0	55.8
	2023	2.0	29.8	0.0	0.0	0.6	0.0	0.0	20.0	0.0	0.1	0.0	0.0	52.5
DOI	2021	0.0	8.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.0
	2022	0.0	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.0
	2023	0.0	15.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.2
DOT	2021	0.0	12.4	0.0	0.5	0.0	0.0	0.0	0.0	0.0	6.0	0.8	0.4	20.1
	2022	1.0	18.9	0.0	0.5	0.0	0.0	0.0	0.0	0.0	7.0	0.4	0.0	27.8
	2023	0.0	16.7	0.0	1.0	2.0	0.0	0.0	0.0	0.0	13.0	0.1	0.0	32.8
ED-IES	2021	0.0	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.0
	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	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0

Agency	FY	ACNS	AI	CHuman	CNPS	CSP	EdW	ENIT	EHCS	HCIA	IRAS	LSDMA	SPSQ	Totals
12 NITRD Program Component Areas														
EPA	2021	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.5	3.0	0.0	0.0	0.0	6.5
	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
FDA	2021	0.0	46.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	46.4
	2022	0.0	40.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	40.6
	2023	0.0	41.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	41.6
NARA	2021	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
	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
NASA	2021	0.0	2.9	0.0	1.8	0.0	0.0	0.0	2.5	61.8	21.9	0.0	1.8	92.6
	2022	0.0	2.9	0.0	1.8	0.0	0.0	0.0	3.5	69.6	22.3	0.0	1.8	101.7
	2023	0.0	4.0	0.0	1.9	0.0	0.0	0.0	3.6	71.4	24.2	0.0	1.8	106.8
NIH	2021	43.7	178.2	331.6	21.8	5.8	55.3	0.0	76.3	331.0	16.9	771.4	176.3	2,008.3
	2021-S	0.0	0.9	10.2	0.0	0.5	2.3	0.0	9.9	9.0	0.0	12.9	3.7	49.4
	2022	45.4	185.0	349.4	23.2	6.0	57.9	0.0	79.7	348.5	17.6	805.2	183.2	2,101.1
	2022-S	0.0	0.3	0.4	0.0	0.0	0.2	0.0	0.5	2.0	0.0	2.0	1.0	6.4
	2023	45.0	183.9	350.5	25.5	5.9	58.4	0.0	83.4	399.3	18.0	811.8	186.6	2,168.3
NIJ	2021	0.0	9.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.1
	2022	0.0	10.3	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.7	0.0	11.2
	2023	0.0	10.3	0.0	0.0	0.2	0.7	0.0	0.0	0.0	0.0	0.7	0.0	11.9
NIOSH	2021	0.0	3.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.3	0.0	0.0	7.0
	2022	0.0	3.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.9	0.0	0.0	7.6
	2023	0.0	3.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.9	0.0	0.0	7.7
NIST	2021	18.0	25.9	22.7	11.4	83.9	18.8	0.0	9.3	9.6	10.2	33.6	3.3	246.7
	2022	13.0	26.6	14.7	9.0	85.4	6.4	0.0	8.8	10.0	11.9	17.6	3.0	206.4
	2023	28.0	40.7	7.6	9.0	101.7	6.2	0.0	8.8	10.0	10.6	13.9	3.0	239.5
NOAA	2021	4.3	1.2	0.2	0.0	0.0	0.0	0.0	0.0	65.5	0.0	0.0	3.7	74.8
	2022	4.3	1.6	0.2	0.0	0.0	0.0	0.0	0.0	70.5	0.0	0.0	3.7	80.2
	2022-S	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	90.0	0.0	0.0	10.0	100.1
	2023	4.3	1.6	0.2	0.0	0.0	0.0	0.0	0.0	95.5	0.0	0.0	3.7	105.2
NSF	2021	186.8	395.9	96.7	79.9	102.1	93.9	61.3	179.2	191.5	45.6	219.2	62.5	1,714.6
	2021-S	6.8	4.8	0.8	1.5	1.1	27.8	0.8	0.1	0.4	0.0	2.0	0.0	46.1
	2022	181.1	438.6	91.1	107.5	108.4	99.2	56.1	163.0	172.3	49.5	188.6	71.7	1,727.1
	2023	221.4	491.2	102.6	141.5	129.3	132.7	104.2	180.8	209.2	63.4	250.1	81.3	2,107.7
NTIA	2021	10.8	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.0
	2022	11.9	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.1
	2023	11.7	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.0
Treas./FinCEN	2021	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
	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
	2022-S	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	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
USDA	2021	0.0	145.2	0.0	6.2	0.0	0.1	0.0	0.0	0.0	5.2	1.0	0.0	157.7
	2022	0.0	145.2	0.0	6.2	0.0	0.1	0.0	0.0	0.0	5.2	1.0	0.0	157.7
	2023	0.0	147.8	0.0	6.2	0.0	0.1	0.0	0.0	0.0	5.2	1.0	0.0	160.3

		12 NITRD Program Component Areas												
Agency	FY	ACNS	AI	CHuman	CNPS	CSP	EdW	ENIT	EHCS	HCIA	IRAS	LSDMA	SPSQ	Totals
VA	2021	14.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.8
	2021-S	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
	2022	22.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	22.8
	2022-S	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7
	2023	42.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	42.0
Totals	2021	599.4	1,578.2	644.0	164.3	711.8	283.5	396.9	445.0	1,576.0	239.3	1,248.9	310.0	8,197.2
	2021-S	32.9	5.7	16.0	1.5	11.5	30.1	0.8	19.9	9.4	0.0	19.8	3.7	151.3
	2022	554.7	1,733.7	635.1	178.4	692.4	339.9	482.0	478.5	1,576.4	353.5	1,242.8	307.9	8,575.3
	2022-S	28.1	0.4	4.2	0.0	3.2	0.2	0.0	35.5	92.0	4.8	7.0	11.0	186.3
	2023	659.7	1,831.1	649.5	222.2	718.3	381.6	825.4	516.9	1,812.6	386.0	1,320.6	292.0	9,615.7

Table 2.1-1 Notes:
- The ACNS PCA is formerly the LSN PCA.
- Fiscal years with "-S" after them denote supplemental funding.
- Amounts are in U.S. dollars in millions.
- Budget supplemental figures for FY 2021 and FY 2022 have not been used to calculate changes between the FY 2021 and FY 2022 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, DHS CWMD, DHS S&T, and DHS TSA; DoD: DTRA, MDA, Military Services' research organizations, and OSD; DOE: DOE/AITO, DOE/ARPA-E, DOE/CESER, DOE/EERE, DOE/FE, DOE/NE, DOE/OE, and DOE/SC; DOE/NNSA: Defense Nuclear Nonproliferation and Defense Programs; DOI: DOI/BSEE, DOI/USBR, and DOI/USGS; DOT: FAA, FHWA, FMCSA, FRA, FTA, and PHMSA; NASA: Aeronautics, Space Technology, and Office of Science; NOAA: NOAA/ORF and NOAA/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 2.1-3 and 2.1-4 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

The NITRD agencies' requested nondefense investment in AI R&D for FY 2023 (Table 2.1-2) is $1.8 billion, an increase of approximately 5.9 percent compared to the $1.7 billion originally requested for nondefense AI R&D for FY 2022.[23] DoD investments are now included in the AI R&D crosscut and future comparisons will be inclusive of defense investments, rather than non-defense only.

Note: For the FY column, FY 2021 refers to actual budget, FY 2022 refers to enacted budget, and FY 2023 refers to budget request. Fiscal years with "-S" after them denote supplemental funding.

Table 2.1-2. Agency Budgets by NITRD PCA for AI R&D, FYs 2021–2023

		Agencies' AI Budgets												
	FY	AI	ACNS	CHuman	CNPS	CSP	EdW	ENIT	EHCS	HCIA	IRAS	LSDMA	SPSQ	Totals
DARPA	2021	412.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	412.0
	2022	456.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	456.7
	2023	412.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	412.4

	FY	AI	ACNS	CHuman	CNPS	CSP	EdW	ENIT	EHCS	HCIA	IRAS	LSDMA	SPSQ	Totals
							Agencies' AI Budgets							
DHS/ Coast Guard	2021	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
	2022	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
	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
DHS/ CWMD	2021	2.7	0.8	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.0	5.8
	2022	2.5	0.2	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	6.3	0.0	9.7
	2023	2.5	0.6	0.0	1.4	0.0	0.0	0.0	0.0	0.0	0.0	2.2	0.0	6.6
DHS/ S&T	2021	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
	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	29.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29.0
DHS/ TSA	2021	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
	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
DoD/ Army	2021	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
	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	84.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	84.6
DoD/ DAF	2021	47.1	6.4	4.0	0.0	15.6	0.0	2.1	2.1	0.0	5.6	13.6	0.0	96.5
	2021-S	0.0	7.7	0.0	0.0	2.5	0.0	0.0	2.5	0.0	0.0	4.9	0.0	17.6
	2022	54.2	8.0	4.2	0.0	23.3	0.0	1.6	2.7	0.0	6.8	21.8	0.0	122.7
	2022-S	0.0	8.1	0.0	0.0	0.0	0.0	0.0	8.8	0.0	0.0	5.0	0.0	21.9
	2023	72.6	8.2	4.4	0.0	26.2	0.0	0.3	3.7	0.0	4.9	16.8	0.0	137.1
DoD/ DTRA	2021	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2
	2022	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7
	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
DoD/ Navy	2021	44.0	0.0	7.9	0.0	0.0	6.9	0.0	0.0	0.0	3.9	63.3	0.0	126.0
	2021-S	0.0	0.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5
	2022	62.8	0.0	8.0	0.0	0.0	10.5	0.0	0.0	0.0	3.7	62.0	0.0	146.9
	2022-S	0.0	0.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	2.5
	2023	76.7	0.0	8.3	0.0	0.0	10.1	0.0	0.0	0.0	3.0	56.0	0.0	154.2
DoD/ OSD	2021	12.7	0.0	0.0	0.0	0.0	0.0	0.0	1.4	0.0	2.2	4.0	0.0	20.2
	2022	9.3	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.0	2.8	5.3	0.0	18.8
	2023	7.6	0.0	0.0	0.0	0.0	0.0	0.0	2.1	0.0	1.9	3.2	0.0	14.8
DOE/ AITO	2021	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.5
	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	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
DOE/ EERE	2021	29.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29.4
	2022	28.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	28.2
	2023	31.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	31.3

	FY	Agencies' AI Budgets												Totals
		AI	ACNS	CHuman	CNPS	CSP	EdW	ENIT	EHCS	HCIA	IRAS	LSDMA	SPSQ	
DOE/FE	2021	29.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29.5
	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
DOE/NE	2021	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
	2022	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
	2023	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6
DOE/ NNSA	2021	29.9	0.0	0.0	0.0	0.1	0.0	0.0	0.7	0.0	0.0	0.0	0.0	30.8
	2022	29.6	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29.9
	2023	29.8	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.1
DOE/OE	2021	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
	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	6.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.5
DOE/SC	2021	83.9	0.0	0.0	0.0	0.0	0.0	0.0	14.9	41.0	0.0	0.0	0.0	139.8
	2022	69.8	0.0	0.0	0.0	0.0	0.0	0.0	16.4	43.6	0.0	0.0	0.0	129.8
	2023	96.0	0.0	0.0	0.0	0.0	0.0	0.0	19.8	53.2	0.0	0.0	0.0	169.0
DOI/ BSEE	2021	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7
	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	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5
DOI/ USBR	2021	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
	2022	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7
	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
DOI/ USGS	2021	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
	2022	8.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.8
	2023	14.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.7
DOT/ FAA	2021	5.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.9
	2022	7.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.6
	2023	7.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.9
DOT/ FHWA	2021	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
	2022	3.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.2
	2023	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
DOT/ FMCSA	2021	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
	2022	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2
	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
DOT/ FRA	2021	2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3
	2022	4.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.9
	2023	4.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.6

| | FY | **Agencies' AI Budgets** | | | | | | | | | | | | |
		AI	ACNS	CHuman	CNPS	CSP	EdW	ENIT	EHCS	HCIA	IRAS	LSDMA	SPSQ	Totals
DOT/ FTA	2021	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
	2022	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
	2023	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/ PHMSA	2021	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2
	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
ED-IES	2021	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.0
	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	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
FDA	2021	46.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	46.4
	2022	40.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	40.6
	2023	41.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	41.6
NARA	2021	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
	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
NASA/ AERO.	2021	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
	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
NASA/ SCIENCE	2021	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.5
	2022	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.5
	2023	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.5
NIH	2021	178.2	0.4	71.6	4.7	1.9	6.2	0.0	37.2	43.4	5.3	137.3	39.1	525.3
	2021-S	0.9	0.0	7.7	0.0	0.0	0.7	0.0	2.2	1.0	0.0	1.3	3.3	17.1
	2022	185.0	0.5	75.5	5.0	2.0	6.5	0.0	38.8	45.7	5.5	143.3	40.7	548.4
	2022-S	0.3	0.0	0.3	0.0	0.0	0.1	0.0	0.1	0.2	0.0	0.2	0.9	2.1
	2023	183.9	0.5	75.7	5.5	1.9	6.5	0.0	40.6	52.3	5.6	144.5	41.4	558.6
NIJ	2021	9.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.1
	2022	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	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
NIOSH	2021	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
	2022	3.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.7
	2023	3.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.7
NIST	2021	25.9	0.7	0.0	0.0	0.0	0.0	0.0	2.4	0.0	3.1	0.0	0.0	32.1
	2022	26.6	0.3	0.0	0.0	0.0	0.0	0.0	2.4	0.0	3.2	0.0	0.0	32.4
	2023	40.7	0.6	0.0	0.0	0.0	0.0	0.0	2.4	0.0	3.2	0.0	0.0	46.8

	FY	Agencies' AI Budgets												
		AI	ACNS	CHuman	CNPS	CSP	EdW	ENIT	EHCS	HCIA	IRAS	LSDMA	SPSQ	Totals
NOAA/ORF	2021	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	2.1
	2022	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	0.0	0.0	0.0	2.9
	2023	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	0.0	0.0	0.0	2.9
NOAA/PAC	2021	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.2
	2022	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.2
	2022-S	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.2
	2023	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2
NSF	2021	395.9	39.6	30.5	26.2	26.3	9.6	11.9	12.7	15.7	45.6	55.0	4.6	673.6
	2021-S	4.8	0.3	0.2	0.3	0.2	1.6	0.1	0.0	0.0	0.0	0.5	0.0	8.1
	2022	438.6	22.8	28.7	22.8	24.9	7.0	2.4	13.0	13.1	28.0	47.3	5.2	653.8
	2023	491.2	20.4	26.4	19.2	22.9	8.5	2.5	10.7	13.4	31.3	46.3	5.3	698.0
NTIA	2021	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2
	2022	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2
	2023	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
USDA-ARS	2021	21.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	21.3
	2022	21.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	21.3
	2023	23.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	23.9
USDA-NIFA	2021	123.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	123.9
	2022	123.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	123.9
	2023	123.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	123.9
Totals	2021	1,578.2	48.0	113.9	31.9	44.0	22.7	14.0	71.9	101.1	65.7	274.5	43.8	2,409.6
	2021-S	5.7	8.1	9.4	0.3	2.7	2.3	0.1	4.7	1.0	0.0	6.7	3.3	44.3
	2022	1,733.7	31.8	116.4	28.5	50.5	24.5	4.0	75.2	103.8	50.0	286.1	45.9	2,550.3
	2022-S	0.4	8.1	1.8	0.0	0.0	0.1	0.0	8.9	0.3	1.0	5.2	1.0	26.6
	2023	1,831.1	30.1	114.7	26.1	51.3	25.1	2.8	79.8	120.3	50.0	269.0	46.8	2,647.3
Non-Defense Totals	2021	1,061.2	41.6	102.1	31.9	28.3	15.8	11.9	68.4	101.1	53.9	193.6	43.8	1,753.7
	2021-S	5.7	0.3	7.9	0.3	0.2	2.3	0.1	2.2	1.0	0.0	1.8	3.3	25.2
	2022	1,073.7	23.8	104.2	28.5	27.2	14.0	2.4	71.2	103.8	36.7	197.0	45.9	1,728.2
	2022-S	0.4	0.0	0.3	0.0	0.0	0.1	0.0	0.1	0.3	0.0	0.2	1.0	2.2
	2023	1,177.2	22.0	102.1	26.1	25.1	15.0	2.5	74.0	120.3	40.2	193.0	46.8	1,844.2

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

Table 2.1-2 Notes:
- The ACNS PCA is formerly the LSN PCA.
- Fiscal years with "-S" after them denote supplemental funding.
- Amounts are in U.S. dollars in millions.
- Budget supplemental figures for FY 2021 and FY 2022 have *not* been used to calculate changes between the FY 2021 and FY 2022 budget numbers.
- For full names of agency subcomponents (departments and offices), please see Appendix A. NASA/Aero. refers to NASA aeronautics programs.
- 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).
- DOE/NNSA Defense Programs reported AI R&D investments in the EHCS PCA.

2.1.3   Agency Budgets for NSF-Led National AI Research Institutes

All NSF-led National AI Research Institutes are requesting a total of $98.4 million for FY 2023, including NSF, DHS, DoD, Department of Education Institute of Education Sciences (ED-IES), NIST, and Department of Agriculture National Institute of Food and Agriculture (USDA-NIFA) investments (Table 2.1-3).

Note: For the FY column, FY 2021 refers to actual budget, FY 2022 refers to enacted budget, and FY 2023 refers to budget request.

Table 2.1-3. Agency Budgets for NSF-Led National AI Research Institutes, FYs 2021–2023

FY	Agencies						Totals
	NSF	DHS	DoD	ED-IES	NIST	USDA-NIFA	
2021	62.8	3.4		10.0	4.0	16.0	96.2
2022	49.3	2.0			2.0	20.0	73.3
2023	70.4	2.0	2.0	2.0	2.0	20.0	98.4

Notes for Table 2.1-3:
- Amounts are in U.S. dollars in millions.
- Totals might not sum exactly as a result of rounding.
- Industry and other private partners will contribute to some National AI Research Institutes (see Section 5.0).

2.1.4   NITRD Agency Budgets for Advanced Wireless Networking R&D

Agencies' budget requests for FY 2023 AWN R&D (Table 2.1-4) total $254.3 million, an increase of approximately 9.6 percent compared to the $232.1 million originally requested for AWN R&D for FY 2022.[24]

Note: For the FY column, FY 2021 refers to actual budget, FY 2022 refers to enacted budget, and FY 2023 refers to budget request. Fiscal years with "-S" after them denote supplemental funding.

---

[24]   https://www.nitrd.gov/pubs/FY2022-NITRD-NAIIO-Supplement.pdf

Table 2.1-4. NITRD Agency Budgets for AWN R&D, FYs 2021–2023

FY	Agencies							TOTALS
	DARPA	DoD/Navy	DOE/NNSA	DOT/FRA	NIST	NSF	NTIA	
2021	27.0	12.3	0.8	0.0	9.0	130.9	10.3	190.2
2021-S	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.6
2022	26.5	12.8	1.6	1.0	8.7	130.2	11.3	192.1
2022-S	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2023	39.4	16.7	2.0	0.0	18.8	166.3	11.1	254.3

Notes for Table 2.1-4:
- Figures break out those portions of NITRD member agencies' R&D investments in the ACNS PCA (formerly LSN) 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/NNSA and DOT/FRA 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 2022 to FY 2023

Table 2.2-1 shows changes of investment greater than $10 million, by agency and PCA, between the FY 2022 enacted budgets and the FY 2023 budget requests.

Table 2.2-1. Changes of >$10 Million in Investment

Agency	Description
DARPA	The increase of $222.2 million is due to increases of $298.2 million in ENIT for significant program enhancements in DARPA's Electronics Resurgence Initiative (ERI) program, $23.2 million in ACNS, and $13.4 million in LSDMA for Resilient Supply and Demand Networks new start program in FY 2023. These are partially offset by decreases of $68.3 million in CSP from the completion of several cyber programs in FY 2023 and $44.3 million in AI from the ramping down of several DARPA AI programs from FY 2022 to FY 2023 (DARPA's AI Next Campaign ends in FY 2024).
DoD	The increase of $86.6 million is due to increases of $62.9 million in HCIA, $38.2 million in AI, $16.0 million in IRAS, and smaller increases in ACNS, CHuman, and CSP; these increases are partially offset by decreases of $28.9 million in SPSQ and $12.7 million in EdW, and smaller decreases in other PCAs.
DOE	The increase of $190.1 million is a result of increases of $54.7 million in HCIA at DOE/SC for support DOE's Earthshot efforts, including the establishment of new Energy Earthshot Research Centers and transitioning the exascale ecosystem into the core research program; $40 million in CSP at DOE/CESER for a new R&D project under the Risk Management Tools and Technologies area; $26.2 million in AI crosscut (non-add) at DOE/SC for foundational AI research and new AI partnerships with DOE Scientific User Facilities; $11.1 million in EdW at DOE/EERE to increase outreach and raise awareness of research and job opportunities, and expand STEM pipeline development programs and new research partnerships with MSIs; and $10.0 million in EdW at DOE/SC for increasing outreach to underrepresented groups and the Computational Sciences Graduate Fellowship. These are partially offset by a decrease of $18.2 million at DOE/SC, with smaller increases and decreases in other programs and PCAs.
NIH	The increase of $67.2 million is a result of an increase of $50.8 million in HCIA for creating a computable cell-type atlas of the whole human brain and other computational research supported by the BRAIN initiative, new efforts in creating a COVID-RADx data management and analysis program and in supporting computational research in the co-occurrence of opioid use and mental health disorders, and smaller increases and decreases in other PCAs.

Agency	Description
NIST	The increase of $33.1 million is a result of increases in CSP resources to meet increased industry and government demands for standards, guidelines, best practices, and other cybersecurity resources; in ACNS to provide measurements and data needed for development of next-generation wireless communications systems and improvement to optical communication technologies; and in AI for expansion of the R&D portfolio to catalyze research, cultivate trust, advance innovation, and make progress toward solving critical AI-centric challenges. These increases are offset by smaller decreases in other PCAs.
NOAA	The increase of $25 million is entirely the result of an increase in HCIA from the Extending Government Funding and Delivering Emergency Assistance Act (PL 117-43) for improvements to weather and climate supercomputing research; hurricane intensity and track prediction; precipitation and flood prediction, forecasting, and mitigation; and wildfire research, prediction, detection, and forecasting.
NSF	The increase of $380.6 million across all PCAs is related to the overall increase to enhance fundamental R&D and strengthen U.S. leadership in emerging technologies. Funding for the new NSF Directorate for Technology, Innovation and Partnerships primarily contributes to larger than average increases in the CNPS, EdW, ENIT, and LSDMA PCAs.
VA	The increase of $19.2 million is entirely the result of an increase in the AI PCA for a National AI Institute at VA, applied health R&D, and trustworthy AI work.

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)[25] 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, Air Force, Army DEVCOM C5ISR Center, Census, CISA, DARPA, DEA, DHS S&T, DOE/SC, DOL, DREN, FCC, FDA, GSA, NASA, Navy, NIH, NIST, NOAA, NSA, NSF, NTIA, ODNI, ONR, OSD (OUSD(R&E)), USDA-ARS, USGS

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.

- Advance quantum communications and networking. *AFRL, DOE/SC, NIST, NSF*

- Advance space-based communications. *DARPA*

- Assess terahertz viability for use in Air Force airborne environments. *AFRL*

- Deploy next-generation high-performance wide area networks. *DOE/SC, DREN*

- Develop new technologies, programmable measurement techniques, methodologies, resilient and intelligent next-generation networks and systems, and testbeds and demonstration capabilities (e.g., 5G architecture and in-network computing and storage). *DARPA, DOE/SC, DREN, NIST, NOAA, NSA, NSF*

- Incorporate AI/ML aspects for better adaptation to the communications layer in convergent networks. *NSF, ONR*

- Provide connectivity/communications in contested and congested environments. *AFRL, Army DEVCOM C5ISR Center, DARPA*

---

[25]   Formerly the LSN PCA

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*

- Connect tactical information across multiple domains on demand, at scale, and securely. *AFRL, DARPA*

- Develop roadmaps for adoption of cloud computing technologies and commercial cloud use. *DOE/SC, NIH, NIST*

- Operationalize N-Wave cloud broker services and support direct connects to commercial cloud. *DREN, NOAA*

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

- 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*

- Develop an end-to-end, virtualized, programmable, self-optimizing network architecture. *DARPA, NSF, ONR*

- Enhance advanced, distributed computing architecture capabilities and next-generation supercomputing support for science needs. *DOE/SC, DREN, NIH, NOAA, NSF*

- Explore the capabilities of AI/ML to enhance data analytics on programmable and 5G/NextG networks. *AFRL, Army DEVCOM C5ISR Center, NSA, NSF, OUSD(R&E)*

- Provide command and control and situational awareness capabilities. *AFRL, DARPA*

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

- Enhance cybersecurity awareness, protections, and capabilities through developing new services and/or tools (e.g., cybersecurity for IoT, AI tools). *AFRL, Army DEVCOM C5ISR Center, DHS S&T, 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 development and testing of resilient and intelligent NextG systems. *DoD, NIST, NSF, industry partners*

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

- 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*

- Deploy and operate nationwide testbeds supporting performance monitoring and protocol development. *AFRL, DOE/SC, NSF*

- Develop and operate testbeds supporting test and evaluation of radio access network disaggregation technologies, develop and operate testbeds supporting test and evaluation of open-source implementations of next-generation network components, and develop standards for evolution of spectrum sharing between 5G/NextG systems and other incompatible radio systems. *NSF*

- Develop nontraditional waveforms and technologies for resilient communications. *Army DEVCOM C5ISR Center, DARPA, NSF, ONR*

- Develop techniques to improve trust, performance, and robustness of wired and wireless networked sensors and control systems. *NIST, NSA, NSF*

- Expand wireless service and deploy rapid, mobile site deployments. *NOAA*

3.1.1.2   Key Coordination Activities

- Advance integration of advanced wireless with large scientific instruments; Advanced network protocol development. *DOE/SC, DREN, NIST, NOAA, NSA, NSF*

- Federal IPv6 Task Force: Communicate frequently with Federal agencies, industry, and other stakeholders on IPv6-only adoption progress among Federal agencies. *CISA, DOJ, DREN, GSA, NIST, OMB*

- High-fidelity whole system modeling and simulation methods and algorithms. *DoD, DOE/SC, NSF*

- LSN Broadband Research and Development Team: Coordinate strategies to address disparities in nationwide broadband access, adoption, and usage, and update the *National Broadband Research Agenda*. *Census*, *DOE/SC, DOI, DOL, FCC, NIJ, NIST, NSF, NTIA, OSD, USDA*

- LSN Joint Engineering Team (JET):[26] 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*

- Middleware and Grid Interagency Coordination (MAGIC) team:[11] 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, USDA-ARS*

- Next-generation network innovations; Scientific Computing: Open Science Grid, CC* Science DMZ, Field Programmable Gate Array Accelerator Research Infrastructure Cloud. *DoD, DOE/SC, NSF*

- N-Wave Stakeholders and Science Engagement Summit: Share initiatives that may present new challenges and opportunities in leveraging shared network resources, and discuss current and future data- and network-related needs to aid in network capacity planning. *DoD, NIST, NOAA, NTIA*

---

[26] Both the JET and MAGIC teams hold information-sharing meetings among Federal and non-Federal participants

- Platforms for Advanced Wireless Research: Support advanced wireless research platforms conceived by the U.S. academic and industrial wireless research community. *FCC, NSF*
- Pursue distributed infrastructure architectures that integrate instruments, sensors, computers, storage, and networks into a coherent whole. *DOE/SC, DREN, NIST, NOAA, NSA, NSF*
- Secure Systems Research: Secure and Trustworthy Cyberspace Program, 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 a 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, DARPA, DEA, DHS, DOE/NNSA, DOE/SC, DOJ (NIJ), FAA, 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.

3.1.2.1 Strategic Priorities and Associated Key Programs

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

1. Expand communications capacity through the dynamic use of multiple frequency bands, modulation techniques, or spectrum sharing methods.

- Deliver adaptable waveforms that are tailored to the mission and spectral environment; Manage interference with tactical infrastructure. *AFRL, Army DEVCOM C5ISR Center, DARPA, NASA, Navy*
- Develop air-to-air capability for long-range ultrabroadband terahertz communications; understand mmWave channel characteristics in real-life deployments; and demonstrate effective, secure unmanned aircraft system and wideband communications in mmWave bands. *AFRL, DOE/NE, NIST, NSF, NTIA*
- Develop laser airborne terminals with radio frequency (RF) networking for increased capacity, robustness, and capabilities to move data into and out of space; Infuse RF capabilities in higher frequency bands; Characterize channel effects; Improve beacon transmission and data collection. *AFRL, Air Force, NASA, NIST, NRL, NSF*
- Develop measurements and modeling parameters of skyward aggregate emissions (5G mmWave and beyond) to support interference impact analysis of terrestrial to non-terrestrial systems. *NIST*
- Develop mid-band propagation modeling and mmWave extensions to propagation models, and analyze effects of radar sharing with new 5G systems. *DoD, NIST, NSF, NTIA*

- Enable wireless communications that are spectrum-efficient, energy-efficient, secure, and adaptable for co-location and relocation through development of new methods, models, and measurements, along with appropriate definitions of spectrum efficiency across space, frequency, and time, including for new 5G systems. *Army DEVCOM C5ISR Center, DARPA, DEA, DHS S&T, DOE/NE, FCC, NIST, NSF, NTIA*

2. Identify and support capabilities for devices to monitor their spectrum environments and adapt in real time, including threat assessments and vulnerability detection.

- Address fundamental needs of spectrum sharing via spectrum sensing and modeling; Address wireless coexistence metrology; Develop new metrology tools for 5G communications systems to ensure trusted spectrum sharing. *DoD, NIST, NSF*

- Conduct integration and independent testing of new and emerging technologies (e.g., IoT, 5G). *DHS S&T, DoD, NIST*

- Develop ML techniques for spectrum access systems and environmental sensing capability sensors and systems for signal classification. *DARPA, DEA, DOE/NE, FCC, NIST, NSF, NTIA*

- Develop signal processing techniques for passive and active RF sensors to remove and/or mitigate effects of RF interference via passive and active RF sensors and via collaborative data sharing. *NASA, NSF*

- Electromagnetic Spectrum Monitoring: Share spectrum situational awareness using ML, visualization, and network-based techniques for collaborative planning and decentralized decision making; Develop infrastructure and best practices to acquire data and facilitate data sharing. *AFRL, DARPA, DHS S&T, DOE/NE, FCC, NIST, NSF, NTIA*

- Implement innovative approaches to enhance communication and network security, including RF, analog, mixed signal, protocol, and/or algorithmic techniques. *NIST, NSF*

3. Develop trustworthy data-driven algorithms and analytics to inform spectrum policy and management.

- Develop algorithms to support cognitive management of multiple radios operating in the same environment. *DEA, DoD, NSF*

- Develop algorithms using RF data, and develop curated datasets and methodology for AI/ML. *NIST, NSF*

- Develop automatic spectrum management mechanisms to dynamically control RF interference; Develop analysis techniques for interference risks and security vulnerabilities of automatic spectrum management mechanisms. *NSF*

- Leverage sensing data to access spectrum, and leverage AI frameworks to ensure effective spectrum utilization and coordination. *NIST, NSF*

- Use data science and ML to eliminate assumption-driven decision making. *DoD, NIST, NSF, NTIA*

- Use frequency selection and analytical techniques to improve NASA's spectrum access. *NASA*

4. Pursue R&D leading to robust, resilient, and reliable spectrum-dependent systems and networks that promote electromagnetic spectrum compatibility, coexistence, and reuse.

- Deploy experimental networks, and explore trust and coexistence between different types of wireless networks; Expand to 5G wideband encryption and optimized massive multiple input/multiple output security; Enable anti-jamming, low probability of detection, interception, and exploitation. *DEA, DHS, DoD, DOE/NE, NSF*

- Develop evaluation methods for 5G and beyond system integration in mission-critical applications, adequate test methods for 5G-enabled medical devices, and medical device wireless coexistence evaluation methods for emerging technologies. *FDA*

- Develop new metrology to support development and evaluation of industrial IoT. *NIST*

- Develop new ways to evaluate, deploy, and protect wireless systems; Use AI/ML to enable an autonomous communications infrastructure; Leverage AI frameworks to ensure effective spectrum utilization and coordination. *NIST, NSF*

- Develop techniques for joint communications and sensing, and repurposing existing wireless signals for sensing (e.g., vital signs, sleep monitoring, motion detection). *NSF*

- Operate networks or secure services from the commercial sector to provide space communication services. *NASA*

- Provide secure tactical intranet working for military communications through multibeam directional connectivity and airborne data exchange between security domains, and improve unmanned aircraft system security measures. *AFRL, DOE/NE, Navy, NSA*

- Support research advances as well as development and testing of resilient and intelligent NextG systems. *DoD, NIST, NSF, industry partners*

5. Accelerate deployment of spectrum R&D into usable tools via testing, modeling, and simulation.

- Develop realistic deep generative machine learning models for RF waveforms and key performance indicators to support rapid interference testing and characterization of black-box communications systems. *NIST*

- Enhance DOE National Laboratory test facilities (e.g., Next-Generation Wireless Testbed); Perform Future City testing. *DOE/NE*

- Establish accurate measurements, system calibrations, technology, and models to address challenges in next-generation wireless communications, spectrum sharing, and wireless coexistence; Develop testing methods in measurement science; Maintain publicly available web-based tools. *DOE/NE, NIST, NTIA*

- Hybrid RF-Optical Link Adaptation Risk Reduction: Demonstrate a hybrid RF-optical link and custom modem to "fail over" to RF as the optical link becomes unavailable to maintain communications. *AFRL, FAA, NASA, NRL*

- Perform extreme environment testing. *DOE/NNSA*

- Present facilities for field trials of advanced wireless systems; Pilot deployments of automatic spectrum management solutions. *NSF*

- Stockbridge Controllable Contested Environment: Create a controllable contested environment where RF transmissions and receptions are completely controlled and measured, enabling R&D on effects of dynamic spectrum access techniques, policy-based routing approaches, and cognitive network node performance. *AFRL, FAA, NASA, NRL*
- Use small satellite, bundled services, and commercial procurement and practices. *NASA*

3.1.2.2 Key Coordination Activities

- 5G-to-Next G Initiative: Invest via Tranche 1 and Tranche 2 DoD base deployments of 5G networks and prototypes in support of new applications and enhancements. *DoD, OUSD(R&E), industry partners*
- 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 stakeholders. *DARPA, DoD, FCC, NIST, academic and industry partners*
- 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*
- International Symposium on Advanced Radio Technologies: Bring together government, industry, and academic leaders (both domestic and international) to forecast development and application of advanced radio technologies. *DARPA, DHS, NSF, NTIA*
- National Academies' Committee on Radio Frequencies: Consider needs for radio frequency 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*
- 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*
- 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/User Experience. *NIST*
- Resilient & 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*
- Spectrum Innovation Zone: Enable testing of new wireless devices, communication techniques, networks, systems, and services in real environments. *FCC, NASA, NSF*
- Supply robust tests and validated measurement data to develop, evaluate, and deploy spectrum sharing technologies. *DoD, NASA, NIST, NOAA, NSF, NTIA*

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: Air Force, Army, BARDA, Census, DARPA, DHS, DIU, DoD CIO, DOE/AITO, DOE/NNSA, DOE/SC, DOJ (NIJ), FAA, FBI, FDA, FMCSA, FTA, GSA, IARPA, JAIC, MDA, NASA, Navy, NHTSA, NIH, NIOSH, NIST, NLM, NMIO, NRO, NSA, NSF, NTIA, ONC, OSD (OUSD(R&E)), OSTP, State, TRMC, USDA-NIFA, USPTO, VA

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

3.2.1.1 Strategic Priorities and Associated Key Programs

Following are the AI R&D IWG's strategic priorities, as defined by the *2019 National AI R&D Strategic Plan*[27] and relevant programs.

1. Make long-term investments in AI research: Coordinate long-term Federal investments in AI R&D that could lead to transformative AI technologies and breakthroughs across all sectors of society.

- Advanced Air Mobility: Support aviation markets to safely develop air transportation system using AI that transports people and cargo between places using revolutionary new aircraft; Lunar Gateway: Provide essential support using AI for long-term human return to lunar surface, and serve as staging points for deep space exploration. *NASA*

- Agriculture and Food Research Initiative: Address research challenges in agriculture using AI. *USDA-NIFA*

- Artificial Intelligence Exchange System: Facilitate extended, diverse AI community by providing holistic view of AI projects and potential to drive focused outcomes. *DOE/AITO, GSA*

- C4I and Software Intensive Systems Test: Provide structured and unstructured data needed by advanced technologies to facilitate timely and accurate extraction of actionable knowledge. *Air Force, Army, TRMC*

- Control and Learning Enabled Verifiable Robust AI: Ensure that AI-based systems are safe. *Navy*

---

[27] https://www.nitrd.gov/pubs/National-AI-RD-Strategy-2019.pdf

- Exploratory Advanced Research Program: Explore and develop AI systems for planning, design, construction, operation, maintenance, and management of Nation's highways. *DOT*

- GURU for AVATAR: Allow untrained users to run simulations in minutes. *Air Force, MDA*

- Information and Intelligent Systems: Study interrelated roles of people, computers, and information to mimic intelligence in computational systems; Computing and Communication Foundations: Advance computing and communication theory, algorithm design and analysis, and architecture and design of computers and software. *NSF*

- Learning with Less Labeling: Make training machine learning models more efficient. *DARPA*

- National AI Research Institutes: Advance multidisciplinary, multi-stakeholder research on large-scale challenges in AI research to help accelerate development of transformational technologies in critical application sectors. *DHS, DOT, ED, NIST, NSF, USDA, industry partners*

- National Artificial Intelligence Institute: Develop AI R&D capabilities for real-world impact and outcomes to ensure Veteran health and well-being; AI Tech Sprint: Enable innovation and product ideation through multi-disciplinary, inter-sectoral collaboration and partnerships. *VA, academic/industry partners*

- Novel Computational Paradigms for AI Hardware: Establish metrics and benchmarks for AI hardware, and provide foundational analysis of physical systems' computational capacity. *NIST*

- Scientific Machine Learning and AI: Develop AI/ML for research across physical sciences and for decision support in managing complex processes to aid in real time decision-making; AI for Science: Identify AI opportunities and explore developing Exascale-like initiative for advancing use of AI in science; Data, AI, and ML at DOE Scientific User Facilities. *DOE*

- Trustworthy and Responsible AI: Identify and quantify trustworthy and responsible AI in technical terms, and develop tools and guidance so that designers, developers, and evaluators can take appropriate actions. *AFRL, Air Force, DoD, DOE, NIH, NIST, NSF*

- Ultrascale Machine Learning to Empower Discovery in Alzheimer's Disease Biobanks: Develop AI methods and apply them to giant databases of genetic, imaging, and cognitive data; Predict respiratory failure and acute respiratory distress syndrome in COVID-19 patients using novel AI/ML system. *NIH*

2. Develop effective methods for human-AI collaboration that attain optimal performance, efficiency, safety, and well-being via advanced AI techniques for human augmentation, visualization, and human-AI interfaces.

- Aegis human-machine teaming. *MDA*

- AI Usability: Develop software and standards to lower barriers for AI-researcher interactions while enhancing AI interpretability and preserving trustworthiness. *NIST*

- Artificial Social Intelligence for Successful Teams: Develop foundational AI theory and systems that demonstrate basic machine social skills needed and actions for human partners to perform; Computational Cultural Understanding: Create cross-cultural language understanding technologies to improve situational awareness and interactional effectiveness; Perceptually-enabled Task Guidance: Develop AI technologies to help users perform complex physical tasks and become more versatile by expanding skillsets and reducing errors. *DARPA*

- Autonomous Discovery in Science and Engineering: Theory, applications, available software packages, and new areas that could benefit from autonomous discovery. *DOE/SC*

- Autonomy Voice Assistant: Enable operator to interact with NASA's autonomy software platform applications through voice conversations; Autonomous Voice Assistant: Using AI to interact with crew during space missions. *NASA*

- Develop advanced AI methods to understand neural mechanisms and to develop automated techniques for kidney donation for transplantation. *NIH*

- Human-Centered Computing: Support research in human-computer interaction to design new computing systems to amplify physical, cognitive, and social capabilities; Human Language Technologies: Improve teaching of collaborative argumentation. *NSF*

- International AI Turing Nobel initiative. *DoD, DOE, NSF, global partners*

- Manned-Unmanned Teaming: Increase situational awareness to conduct operations that include combat support and intelligence, surveillance, and reconnaissance missions. *TRMC*

- Real-time or near real-time decision-making. *DHS*

- Smart-path planning for collaborative robots; Methods for accessing protective materials; Auto-coding of occupational databases; Natural Language Processing of injury/fatality reports; Biomechanical modeling of exoskeleton use; Predict safety and stability of mining engineering. *NIOSH*

3. Understand and address the ethical, legal, and societal implications of AI: Develop design methods for trustworthy AI that align with ethical-legal-societal goals and expectations.

- AI Risk Management Playbook evolution. *DOE/AITO, NASA, NIST, OSTP/NAIIO, industry partners*

- Artificial Intelligence/Machine Learning Consortium to Advance Health Equity and Researcher Diversity (AIM-AHEAD): Increase participation and representation of researchers and communities currently underrepresented in development of AI/ML models; Explanatory Autonomous Relay Agent: Using AI to characterize query results by rating quality of information returned from multi-scale heterogeneous knowledge pools. *NIH*

- Designing Accountable Software Systems: Understanding relationship between software systems and complex social and legal contexts within which they operate. *NSF*

- Evaluation of fairness and lack of bias in ML-based PubMed retrievals. *NLM, NIST*

- Explainable and interpretable AI; Bias in AI; AI transparency; Privacy-preserving ML. *NIH, NIST, NSF*

- Technology policy research. *DHS*

4. Ensure the safety and security of AI systems so that they operate in a controlled, well-defined, and well-understood manner.

- AI ModelOps ecosystem: Measurements, testing, benchmarks, and standards to guide AI system safety, reliability, accuracy, usability, interoperability, robustness, and security. *DOE/AITO, NIH*

- Assured Autonomy: Create technology for continual assurance of learning-enabled cyber-physical systems (CPS); Guaranteeing AI Robustness against Deception: Identify system vulnerabilities, characterize properties that will enhance system robustness, and create effective defenses. *DARPA*

- Assured DevSecOps of Autonomous Systems portfolio pathfinder. *Air Force, Army, DoD CIO, JAIC, Navy, OUSD(R&E), TRMC, USSF*

- Secure AI: Conduct foundational research on metrics and best practices to ensure that AI applications are secure and free from vulnerabilities. *DHS, NIST*

- Secure and Trustworthy Cyberspace: Protect and preserve growing social and economic benefits of cyber systems while ensuring security and privacy. *NSF*

- Software Verification & Validation: Develop and apply automated tools, such as model checkers and static analyzers, in verification and validation of critical software systems; Independent Verification and Validation Program cybersecurity: Ensure safe, reliable, secure operation of safety and mission-critical software. *NASA*

5. Develop shared public datasets and environments for AI training and testing to enable discovery, access, and use.

- Advanced AI-enabled programs: Bridge2AI: Generate new flagship biomedical and behavioral datasets, develop new AI software and standards, and train new researchers in field of biomedical AI; Medical Imaging and Data Resource Center: Accelerate the transfer of knowledge and innovation in the current COVID-19 pandemic and beyond; Making Antibody Generation Rapid, Scalable, and Democratic through ML and Continuous Evolution: Provide a system for the scalable continuous evolution and computational design of antibodies against user-selected antigens; Multiscale Analyses of 4D Nucleome Structure and Function by Comprehensive Multimodal Data Integration: Develop a better understanding of the three-dimensional structure of cell nuclei and how changes in that structure affect cell functions in health and disease. *NIH*

- Advanced Information Systems Technology: Identify, develop, and support adoption of information systems needed by Earth Science Division in next 5–10 years; Advancing Collaborative Connections for Earth System Science: Develop and implement technologies to effectively manage, discover, and utilize Earth observations data. *NASA*

- Cybersecurity and Infrastructure Security Agency (CISA) Advanced Analytics Platform for Machine Learning: Offer multi-cloud environment where new tools and software can be researched and tested against live data. *DHS*

- Findable, Accessible, Interoperable, and Reusable (FAIR) Data and Models for AI and ML: Make data and models reusable by AI application developers and researchers through attention to FAIR Data Principles. *DOE/SC*

- Joint Automated Repository for Various Integrated Simulations: Automate materials discovery and optimization using classical force-field, density functional theory, machine learning calculations, and experiments. *NIST*

- Open Knowledge Networks: Support R&D for repositories that support broad public use cases and address national priorities, spanning science, engineering, health, and commerce; Cyberinfrastructure for Sustained Scientific Innovation (CSSI): Integrated cyberinfrastructure services, quantitative metrics with targets for delivery and usage of these services, and AI resources. *NSF*

- Privacy-preserving AI research: Basic research for federated learning and the development of predictive models from collectively shared, privacy-sensitive datasets. *DHS, DOE/SC, NIH*

- Trusted Spectrum Testing: Provide robust test processes and validated measurement data necessary to develop, evaluate, and deploy spectrum sharing technologies. *DoD, NASA, NOAA, NIST, NSF, NTIA*

6. Measure and evaluate AI technologies through standards and benchmarks to address safety, reliability, accuracy, usability, interoperability, robustness, and security.

- AI standards development. *NIST, all other AI IWG agencies*

- AI validation and evaluation. *DOE/AITO, NIST*

- 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*

- Autonomy, integration, and testing. *Air Force, Army, Navy, TRMC*

- Leading Edge Acceleration Projects (LEAP) in Health IT: Advance development and use of interoperable health IT by addressing emerging and future challenges; Using Machine Learning Techniques to Enable Health Information Exchange to Support COVID-19-Focused Patient-Centered Outcomes Research (PCOR). *ONC*

- Low-Cost Detection of Dementia Using Electronic Health Records Data: Validation and testing of eRADAR Algorithm in Pragmatic, Patient-centered Trial; Data driven strategies for substance misuse identification in hospitalized patients. *NIH*

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.*

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.*

- Accelerating Medicines Partnership: Improve understanding of therapeutically relevant biological pathways and validate information for development of multiple therapeutics. *FDA, NIH*

- Digital Assistants for Science and Engineering: Develop AI/ML-based digital assistants for use onboard for missions and on ground for all facets of R&D. *NASA, SBIR/STTR partners*

- Mission-focused AI and data science challenges. *DOE, NASA, academic partners*

- National Cybersecurity Center of Excellence (NCCoE): Bring together experts to address real-world needs of securing complex IT systems critical infrastructure. *NIST, industry partners*

- Resilient & Intelligent NextG Systems: Accelerate research that will have significant impact on emerging wireless and mobile communication, networking, sensing, and computing systems. *DoD, NIST, NSF, industry partners*

3.2.1.2 Key Coordination Activities

- All of Us Research Program: Establish one-million volunteer group to contribute health data to leverage technology and capitalize on mobile health technology. *NIH, academic/industry partners*

- Aviation Safety Information Analysis and Sharing: Provide repository of commercial flight-recorded data and safety reports, analyzed for safety incidents. *NASA, NTSB, industry partners*

- Biodefense and AI analysis: Sponsor workshops on AI/ML as enabling technology for biodefense research. *DOE, NIST, NSF*

- Brain Summit: Create opportunities for collaboration and spread innovation and best practices across VA in key brain-centric health topics. *VA, other agencies, academic/industry partners*

- Computer Vision: Assess behavior of drivers and pedestrians to improve traffic safety. *FMCSA, FTA, NHTSA, NIH, NIST, NSF*

- COVID-19 Open Research Dataset: Enable researchers to apply novel AI and ML strategies to identify new knowledge about coronaviruses and end pandemic. *NLM, OSTP, industry partners*

- Federal AI Standards Coordinator: Work with government and industry stakeholders to identify critical standards development activities, strategies, and gaps. *NIST, other agencies*

- HHS AI Council: Advance the HHS AI strategy and support AI governance, strategy execution, and development of strategic AI priorities across the enterprise; HHS AI Community of Practice: Share lessons learned, identify AI opportunities, provide peer recommendations for scaling AI use cases, and support shared access to resources, innovation labs, and best practices. *ACL, AHRQ, CDC, CMS, FDA, HRSA, IHS, NIH, ONC, SAMHSA*

- Multidisciplinary University Research Initiative (MURI): Support research teams whose research efforts intersect more than one traditional science and engineering discipline. *DoD*

- National AI Advisory Committee: Provide recommendations on U.S. AI competitiveness, science around AI, AI workforce issues, AI opportunities for international cooperation, and AI opportunities for diverse geographic regions. *NIST, OSTP/NAIIO, academic/industry/ association/consumer advocacy partners*

- Pandemic readiness and prevention. *NIH, NSF*

- Principal Investigator meetings: Review research, identify new applications, and discuss S&T gaps and barriers. *DARPA, DHS, DOE, DOT, NASA, NIH, NIJ, NIOSH, NIST, NSA, NSF, USDA-NIFA*

- RADx programs: RADx-rad: Advance diagnostic technologies through use of AI for screening, diagnosing, and monitoring COVID-19; RADx Tech: Program to speed the development, validation, and commercialization of innovative point-of-care and home-based tests; RADx-UP: Program to lay the foundation to reduce disparities in populations disproportionately affected by the COVID-19 pandemic. *BARDA, CDC, FDA, NIH*

- Research AI system for mitigating waste, fraud, and abuse of legislation: Apply AI/ML for discovery and analytics of infrastructure, energy and climate resiliency, and Justice contracts, proposals, vendor performance, and investment data for waste, fraud, and abuse of awards. *DOE/AITO*

- Science of Autonomy: Focus on multidisciplinary research topics in autonomy and interconnecting fields. *DoD, academic/industry partners*

- Space S&T Partnership Forum: Develop trusted autonomy technologies for use in space. *NASA, NRO, USSF*

- Tech for Social Good: Collaborate on social-impact projects. *NIOSH, academic partners*

- Transportation Systems Management and Operations: Provide improvements that can maintain and restore performance of existing transportation systems before extra capacity is needed. *DOE, FMCSA, FTA*

- 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*

- International collaborations:
  - U.S.-EU Trade and Technology Council. Increase coordination in emerging technologies such as advanced manufacturing, AI, and cybersecurity. *NIST, OSTP, State, EU countries*
  - U.S.-India collaborations. Establish an international partnership framework. *DOE, NIST, NSF, India, Netherlands*
  - U.S.-UK Stocktake Autonomy and AI Working Group: Focus on autonomy and AI-enabled brigade support, collaboration infrastructure and enablers, joint autonomy and AI toolbox, and basic research in autonomous and AI-based systems. *DoD, international government partner*
  - U.S.-Republic of South Korea (ROK) Technology Cooperation Sub-Committee (TCSC) Autonomy and AI Working Group: Focus on cyber defense, autonomous situation awareness, scalable teaming, autonomous drone defense, intelligent understanding of underwater objects, and unmanned ground robot for underground facility use. *DoD, international government partner*

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, Air Force, CDC, CMS, DOJ (NIJ), NASA, Navy, NIH, NIOSH, NIST, NOAA, NSF, ONC, USDA, VA

3.3.1.1 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.

- Care Transition research grants: Fund research to produce evidence and evidence-based tools to improve care transitions. *AHRQ*

- Center for Evidence and Practice Improvement Evidence Discovery and Retrieval: Use technology to make patient-centered outcomes research findings within AHRQ repositories more FAIR. *AHRQ*

- Civic Innovation Challenge: Flip the community-university dynamic, asking communities to identify civic priorities ripe for innovation and then to partner with researchers to address those priorities. *NSF*

- Clinical decision support (CDS) initiative: Help healthcare providers move PCOR evidence into practice through CDS. *AHRQ, CDC, CMS, VA*

- Convergence Accelerator Track F (Trust and Authenticity in Communications): Develop research platforms for increased trust in information. *NSF*

- Designing Accountable Software Systems: Understanding relationship between software systems and complex social and legal contexts within which they operate and methods for better-designing accountable software. *NSF*

- Digital Health Solutions for COVID-19: Research wearable devices, biosensors, and platforms for the early detection of COVID-19. *NIH*

- Digital Healthcare Equity Framework and Guide: Specify aspects that need to be considered when creating and planning for equitable healthcare solutions that involve digital technologies. *AHRQ*

- Digital Healthcare Safety research grants: Fund grant applications that conduct 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*

- Electronic Care (eCare) Plan for people with multiple chronic conditions: Provide open-source, clinician-facing, patient-facing, and caregiver-facing SMART® on Fast Healthcare Interoperability Resources eCare Plan applications and implementation guide. *AHRQ, NIH*

- Explainable AI and Bias in AI Systems programs: Conduct foundational research to build trust in AI systems by improving explainability, transparency, avoiding bias, and preventing discrimination. *NIH, NIST*

- Future of Work at the Human-Technology Frontier: Respond to challenges and opportunities for future of employment in landscape with rapid social and technological changes. *NSF*

- Human-Centered Computing: Integrate knowledge across disciplines—such as the social and behavioral sciences with computer and information sciences—to design new computing systems to amplify diverse humans' physical, cognitive, and social capabilities; to assess benefits, effects, and risks of computing systems; and to understand how human, technical, and contextual aspects of systems interact to shape those effects. *NSF*

- NIH Intramural Research: Provide timely and effortless access to reliable health-related information for decision support and education. *NIH*

- Research on Emerging Technologies for Teaching and Learning: Provide exploratory, synergistic research in emerging technologies for teaching and learning. *NSF*

- Small Business awards: Support a Novel Sensor System to address diseases such as Alzheimer's and to improve healthcare outcomes. *NIH*

- Smart and Connected Communities: Accelerate creation of scientific and engineering 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-NIFA*

- Smart Health and 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*

- Usability and Human Factors research: Understand and measure human interaction with information technology, providing guidance for better design and use. *NIST*

2. Improve interfaces between humans and intelligent systems, including robots, intelligent agents, autonomous vehicles, and machine-learning systems, to accomplish complex missions.

- Augmented Reality (AR) usability: Develop usability testing and usability analysis on AR software solutions across wide range of applications. *NIST*

- Automated Seizure Detection for Home Seizure Monitoring with Epilog Sensors: Create digital health platform with wearable medical device to detect and count seizures, and alert to seizures in real time. *NIH*

- Foundational Research in Robotics: Research robotic systems that exhibit significant levels of both computational capability and physical complexity. *NSF*

- Fuse motor neuroscience and artificial intelligence to create next-generation neural prostheses. *NIH*

- Ghost in the Machine: Melding Brain, Computer and Behavior: Develop revolutionary, new generation of implantable neuro devices that will communicate with, learn from, and teach their human hosts to better treat disease. *NIH*

- 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), service robots, and other interactive robots that may cause human injuries from sources such as unintended contact, collision, vibration, and overexertion. *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 also the EdW PCA.*

- Cybersecurity Framework adoption and awareness. *NIST*

- Develop training resources on the use of technology for law enforcement practitioners. *NIJ*

- Evaluate training that helps workers acquire skills, knowledge, and abilities needed to operate rapidly advancing robots in complex and dynamic industrial environments, considering differences in race, ethnicity, age, sex, and other equity factors. *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*

- Generate resources for patient education. *NIH*

- NIST Phish Scale: Allow organizations to better categorize actual threats (for better detection) and to better determine effectiveness of their phishing training programs. *NIST*

- Provide learning health system institutional mentored career development program. *AHRQ*

- Usable Security: 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*

3.3.1.2 Key Coordination Activities

- CDS Innovation Collaborative: Monthly/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, digital healthcare researchers, healthcare providers*

- 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*

- Public Patient-centered CDS Connect Work Group: AHRQ holds monthly meetings with presentations from CDS Connect users to obtain stakeholder input about CDS repositories and standards-based tools. *CDC, CMS, VA, health IT developers and researchers*

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, Air Force, Army, BLS, DARPA, DHS, DOE, FDA, FHWA, FMCSA, FRA, FTA, ITA, ITS JPO, MARAD, NASA, Navy, NHTSA, NIH, NIST, NRC, NSA, NSF, NTIA, ONR, OSD, USACE/ERDC, USDA-NIFA

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.

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.

- Computer and Information Science and Engineering (CISE) core programs. *NSF*
- Cyber-Physical Systems (CPS): Enable capability, adaptability, scalability, resiliency, safety, security, and usability that will expand horizons of critical systems. *DHS, FHWA, NIH, NSF, USDA-NIFA*
- Develop CPS for agriculture. *NSF, USDA-NIFA*
- Integration of energy and computing networks. *USACE/ERDC*
- NIH Research Project Grant Program: Provide support for health-related R&D based on NIH's mission. *NIH*
- Science and engineering (S&E) foundations of CPS; CPS/IoT research infrastructure; Smart grid interoperability profiles; CPS architecture infrastructure and foundations. *NIST*
- Security and privacy interactions with Internet of Things. *NSF*
- Tools to quantify and ensure Agile software development. *AFRL*

2. Catalyze research and innovation of new and emerging ideas for CNPS to enable safety and security spanning system design, development, assurance, and verification, including applications of AI, digital twins, formal methods, and other concepts emerging from the CNPS IWG as well as related NITRD IWGs.

- Cooperative Automation Research Mobility Applications Platform[SM]: Enable automated driving systems. *DHS, DoD, DOT, FHWA, FMCSA, FTA, ITS JPO, MARAD, NASA, NHTSA, NSF*
- Future Manufacturing cyber track. *NSF*
- ICDI: Effort to prevent coastal flooding using digital twin techniques. *DOE/SC*
- Safety assurance. *DARPA, NASA, NIST, NRC, NSF*
- Self-healing ship systems. *ONR*
- Smart Grid experimental infrastructure; Industrial control systems and blockchain; Electric vehicle integration. *NIST*

3. Develop multi-time-horizon science and technology leading to new capabilities for complex intelligent systems that provide equitable societal resilience and robustness to climate change.

- Civic Innovation Challenge: Fund ready-to-implement, research-based pilot projects with potential for scalable, sustainable, and transferable impact on community-identified priorities. *DHS, DOE, NSF*
- Extension, Education, and USDA Climate Hub Partnerships: Train next generation of agriculturalists and foresters to incorporate climate change research into their management practices. *USDA-NIFA*
- Smart and Connected Systems: Measure, describe, and analyze data to make decisions thereby performing smart actions both with and without human-to-human or human-to-computer interactions. *NIST*
- Systems analysis integration. *NIST*

4. Support advances in smart cities and communities by investing in multidisciplinary, multisector research collaborations that leverage CNPS applications for solutions in areas such as public health and well-being, transportation and mobility, energy, smart infrastructure, agricultural and rural connectivity, emergency management, resilience, public safety, and water management.

- Exploratory advanced research. *FHWA*
- Global City Teams Challenge: Share lessons learned, improve on successes, and build consensus for standards. *ITA, NASA, NIST, NSF, NTIA*
- 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, NSF, USDA-NIFA*
- Smart Cities and Communities Framework: Provide cities and communities with best practices and technical guidelines for planning, developing, and implementing smart solutions. *NIST*

5. Leverage CNPS R&D investment to facilitate multisector technology transfer to public and private systems in an equitable manner that serves vulnerable and underserved communities.

- Consensus-based automated driving systems safety measurement methods. *NHTSA, NIST*

- Formal methods in the field (Transition to Practice track). *NSF*

- Reliable smart grid communications. *NIST*

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

3.4.1.2   Key Coordination Activities

- All of Us Research Program: Establish one-million volunteer participant group reflecting Nation's genealogical and health diversity to contribute health data to leverage technology advances in genomics, computing, and data analytics, and to capitalize on mobile health technology. *NIH, public/private partners*

- CPS Principal Investigator meetings: Assemble CPS researchers and multiple agency partners annually to review CPS research results. *DHS, DoD, DOE, DOT, NASA, NIH, NIST, NSA, NSF, USDA-NIFA*

- Global Cities Team Challenge Action Clusters: Engage stakeholders to develop best practices and projects for foundational elements of smart city ecosystems including such domains as agricultural and rural smart systems, smart buildings, smart regions, and smart states. *DHS, NASA, NIST, NSF, NTIA, USDA-NIFA*

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, Air Force, ARL, Army, C5ISR, DARPA, DHS, DOE/CESER, DOJ (NIJ), DOT, IARPA, Navy, NIH, NIST, NRC, NSA, NSF, ONR, OSD, Treasury, 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.

3.5.1.1 Strategic Priorities and Associated Key Programs: [28] Defensive Capabilities (1–4) and Priority Areas (5–10)

Federal cybersecurity R&D is a substantial portfolio. This section provides thematical highlights of the main lines of research pursued by those programs, mapped against the CSIA strategic priorities. The programs are listed in the accompanying the FY 2023 *Federal Cybersecurity R&D Strategic Plan Implementation Roadmap*. [29]

Following are the CSIA IWG's Defensive Capabilities 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.

- Active social engineering defense and attribution. *DARPA, NSF*

- Autonomous and agile cyber defense. *ARL, DARPA, NSF, OSD*

- Cyber deception. *ARL, DHS, DOE/CESER, NSA, ONR*

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

- Application, network, mobile, and hardware security. *AFRL, ARL, C5ISR, DARPA, DHS, DOE/CESER, NIST, NSA, NSF, ONR, OSD*

- Assured systems. *AFRL, DARPA, NIST, NSA, NSF, ONR, OSD*

- Automated and autonomous cyber defense and operations. *ARL, C5ISR, DARPA, DHS, DOE/CESER, NSA, NSF, ONR*

- Cryptography and formal analysis. *DARPA, NIST, NSA, NSF*

- Resilient cyber, cyber-physical, and IoT systems. *AFRL, ARL, C5ISR, DARPA, DHS, DOE/CESER, NIH, NIST, NSA, NSF, ONR*

- 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 maneuver and resilience. *ARL*

- Cyber situational awareness. *ARL, C5ISR, DARPA, DHS, DOE/CESER, NSA, OSD*

- Information integrity. *NSF, OSD*

- Machine learning for security. *DARPA, DOE/CESER, NIST, NSA, NSF, OSD*

- Malware detection and mitigation. *DARPA, DHS, DOE/CESER, NIST, NSF, ONR*

---

[28] See Federal cybersecurity R&D priorities in https://www.nitrd.gov/pubs/Federal-Cybersecurity-RD-Strategic-Plan-2019.pdf
[29] Link to FY23 Cybersecurity Roadmap when available

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, DARPA, DHS, DOE/CESER, NSA, NSF, ONR, OSD*

- Countering cyber attacks. *DARPA, DHS, NSF, OSD*

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/AITO, DOE/CESER, NIH, NIST, NSA, NSF, ONR, OSD*

- Cybersecurity of AI. *AFRL, ARL, C5ISR, DHS, NIST, NSA, NSF, OSD*

- Standards for AI. *NIH, NIST*

6. QIS: Develop technologies for securing quantum software and hardware and for developing countermeasures against quantum-based attacks.

- Quantum science, programming, and protocols. *AFRL, ARL, DOE/CESER, 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.

- Protection of cyber-physical and IoT systems. *AFRL, DARPA, DHS, DOE/CESER, NSA, NSF, ONR*

- Wireless and network security. *AFRL, ARL, C5ISR, DARPA, DHS, DOE/CESER, NIST, NSA, NSF, OSD*

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.

- Cryptography for privacy. *DARPA, DHS, NIST, NSA, 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.

- Formal verification of software and hardware. *AFRL, DARPA, NSF, ONR*

- Secure microprocessors and IoT. *AFRL, DHS, NSA, NSF*

- Software assurance. *AFRL, DARPA, DHS, DOE/CESER, NIST, NSA, NSF, ONR, OSD*

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.*

3.5.1.2   Key Coordination Activities

- Advanced Course in Engineering: Cybersecurity classes. *AFRL, NSA*

- Advanced Technological Education programs. *NSF*

- Cryptographic standards development. *NIST, NSA*

- Cyber Resilient Energy Delivery Consortium: Research cybersecurity and cyber-resiliency of energy delivery systems for electric power and oil and gas industries. *DOE/CESER, academic/industry partners*

- 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/industry partners*

- Cyber technology demonstrations. *DARPA, NIST, NSA, OSD*

- Cyber/cyber-physical security public working groups. *NIST, academic/industry partners*

- 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*

- Cyber-physical systems security. *DOT, NIST, NSF, academic/industry partners*

- Cybersecurity and privacy research workshops. *NSF*

- DoD Cyber Community of Interest: Provide oversight and coordination among DoD cyber S&T programs. *AFRL, ARL, C5ISR, DARPA, NSA, ONR, OSD*

- Federal Cybersecurity R&D Strategic Plan Implementation Roadmap: Provide annually as directed by Cybersecurity Enhancement Act of 2014. *All CSIA IWG agencies*

- National Centers of Academic Excellence in Cybersecurity: Reduce vulnerability in national information infrastructure by promoting higher education and expertise in cybersecurity. *CISA, NIST, NSA, NSF, USCYBERCOM*

- National Initiative for Cybersecurity Education (NICE) and annual NICE Conference/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/industry partners*

- Standards development and standards setting: 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, OSD*
- International collaborations:
  ◦ 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*
  ◦ 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, Defense Science and Technology Laboratory (UK), NRL, NSA, OSD, USCYBERCOM*
  ◦ Science programs with Israel, Brazil, and Ireland. *NSF*
  ◦ 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, OSD*

3.5.2   *Privacy Research and Development IWG*

Participating Agencies: Census, DOE/SC, FTC, NARA, NIH, NIST, NSA, NSF, NTIA, OSD, 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, NSA, NSF*
- Develop privacy framework and standards-based tools and privacy engineering practices. *NIST*
- Provide methods for secure, privacy-preserving access to precision health data. *NIH, NSF*

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

- Build encryption for privacy protections. *NIH, NSA, 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 privacy enhancing cryptography. *NIST, NSF*

- Develop secure and private collaboration environments. *Census, NIH, NSF*

- Develop techniques to ensure privacy protections in analytical and ML systems. *NIH, NIST, NSA, 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

- Fast-Track Action Committee (FTAC) on Advancing Privacy-Preserving Data Sharing and Analytics: In January 2022, NITRD launched the FTAC on Advancing Privacy-Preserving Data Sharing and Analytics. The FTAC serves as a coordination mechanism for recently started Federal initiatives related to privacy-preserving data sharing and analytics, as well as future domestic and international efforts that may arise in the near term. The FTAC has been tasked to develop a national strategy to advance the research, development, and adoption of privacy-preserving data sharing and analytics technologies. *CDC, Census, DARPA, DHS, DOE/SC, DOL, DOT, ED, GSA, NIH, NIST, NSF, ODNI, State, VA*

- Federal Privacy Council: Participate actively in this interagency forum organized to improve privacy practices of Federal agencies. *FTC, NIST, NSF*

- 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*

- NIST Privacy Framework: Continue collaboration on framework implementation and development of related guidelines and tools. *Federal agencies, private sector stakeholders*

- Privacy Research Workshops: Continue annual workshops on topics such as privacy controls, privacy framework, algorithmic transparency, and consumer privacy protections. *FTC, NIST, NSF*

- Technical privacy guidelines: Develop and coordinate recommendations, guidelines, and standards for privacy-preserving technologies and privacy risk assessment methodologies. *Census, NIST*

- International collaborations:
  - Co-fund privacy research activities with Netherlands, Ireland, and Israel. *NSF*

- ◦ Engage in international privacy standards development. *NIST*
- ◦ Prize challenges in privacy-enhancing technologies: Engage Federal agencies and domestic and international stakeholders in developing innovative privacy-enhancing technologies. *NIST, NSF, UK government*

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: Air Force, Census, DARPA, DHS, DOE/AITO, DOE/NNSA, DOE/SC, DOJ (NIJ), DOT, FCC, FTC, NASA, Navy, NIH, NIST, NSA, NSF, ODNI, ONC, SSA, USDA, USGS, USSF, VA

3.6.1.1 Strategic Priorities and Associated Key Programs

Following are the EdW PCA's strategic priorities and relevant programs. [30]

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.

- CISE Graduate Fellowships: Increase number of diverse, domestic graduate students pursuing research and innovation careers in computer science, computer engineering, or information science. *NSF*

- Computational Science Graduate Fellowship Program: Provide opportunities to students pursuing doctoral degrees in fields that use high-performance computing to solve complex science and engineering problems. *DOE/NNSA, DOE/SC*

- CSSI: Enable funding opportunities that are flexible and responsive to evolving and emerging needs in cyberinfrastructure. *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*

- 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*

- Entrepreneurial Fellowships program. *NSF*

---

[30] 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.

- Graduate Research Fellowship Program: Increase pool of scholars engaged in research that addresses challenges of U.S. crime and justice, particularly at state and local levels. *NIJ*

- NIST International and Academic Affairs Office: Provide advice on international S&T engagement, serve as liaison with international S&T community, manage NIST bilateral and multilateral cooperation, and oversee NIST's cooperation with academia. *NIST*

- NSF Research Traineeship program: Provide graduate students with specialized training and funding assistance to join careers at forefront of technology and innovation. *NSF*

- Quantitative and Computational Biology Graduate Training Program: Facilitate graduate education at Princeton in biology, quantitative sciences, and computation. *NIH*

- Research Experiences for Undergraduates Supplement: Provide support for undergraduate students to participate in research as part of new or ongoing NSF-funded research project. *NSF*

- Research Training Initiative for Student Enhancement: Educating Tomorrow's Biomedical Workforce: Help prepare individuals for careers in biomedical, behavioral, social, and clinical research. *NIH*

- Resources (e.g., software libraries, tools, and platforms) to support teaching and research. *NSF*

- Student access to HPC resources (various programs). *NIST*

- Training in Biomedical Informatics programs. *NIH*

- Women in IT Networking at SC: Program for addressing prevalent gender gap that exists in in the fields of network engineering and high-performance computing. *DOE(SC), 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.

- 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; Computing in Undergraduate Education: Support teams of Institutions of Higher Education in re-envisioning role of computing in interdisciplinary collaboration, and encourage teams to integrate study of ethics into their curricula. *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 mission of their department or organization; CISE Research Initiation Initiative: Support research independence among early-career academicians who specifically lack access to adequate organizational or other resources. *NSF*

- Future of Work at the Human Technology Frontier: Respond to challenges and opportunities for future of jobs and workers in landscape with rapid social and technological changes; Data Science Corps: Build capacity for harnessing data revolution at local, state, and national levels for strong and diverse national data science and AI workforce by engaging students in real-world data projects. *NSF*

- NICE Workforce Framework for Cybersecurity: Provide building blocks for describing tasks, knowledge, and skills needed to perform cybersecurity work by individuals and teams. *NIST*

- 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; Clinical guidance software for nurse education and practitioners to evaluate experiential case files for the purpose of augmenting health disparity/equity clinical care. *NIH*

- Training-based Workforce Development for Advanced Cyberinfrastructure: Prepare, nurture, and grow national scientific research workforce for creating, utilizing, and supporting advanced cyberinfrastructure to enable and transform fundamental science and engineering research and education; Technology and Innovation internships for experiential learning. *NSF*

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 other underrepresented groups in those disciplines. *NSF*

- Data science challenges that engage diverse set of participants to find novel solutions. *DOE/AITO, NIJ*

- Joint Center for Quantum Information and Computer Science: Advance research and education in quantum computer science and quantum information theory. *NIST*

- NCCoE: Bring together experts from industry, government, and academia to address real-world needs of securing complex IT systems; teach others ways to improve their cybersecurity posture. *NIST, academic/industry partners*

- Research on Emerging Technologies for Teaching and Learning: Fund exploratory and synergistic research in emerging technologies (including 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 HCIA PCA.*

- Data and Technology Advancement National Service Scholar Program: Offer experienced data and computer scientists and engineers opportunity to tackle challenging biomedical data problems with potential for substantial public health impact. *NIH*

- High school, undergraduate, graduate, and postdoctoral programs that support education in HPC skills. *NIST*

- HPC Intern Program: Provide outstanding mentors with challenging and rewarding HPC projects that will leverage existing government-wide and local programs to attract the best intern candidates and prospective DoD employees. *DoD*

- Internships, curriculum development, and resource sharing in collaboration with minority serving institutions; Hackathons, tutorials, and workshops. *NASA*

- Joint University Microelectronics Program: Undertake high-risk, high-payoff research that addresses existing and emerging challenges in microelectronic technologies. *DARPA, academic/industry partners*

- Predictive Science Academic Alliance Program: Engage U.S. academic community in advancing science-based modeling and simulation. *DOE/NNSA*

- Reaching a New Energy Sciences Workforce initiative: Increase participation and retention of underrepresented groups in Office of Science research activities; Microelectronics research; HPC; QIS training programs at leadership computing facilities and national laboratories. *DOE/SC*

- Research Education for Undergraduates: Support active research participation by undergraduate students in areas of NSF-funded research; Partnerships for Research and Education in Materials: Enable, build, and grow partnerships between Minority-Serving Institutions and NSF-supported centers and/or facilities to increase recruitment, retention, and degree attainment by those most underrepresented in materials research. *NSF*

5. Build the current and next-generation workforce necessary to develop, support, and use all aspects of big data. *See also the LSDMA PCA.*

- AIM-AHEAD Program: Establish mutually beneficial and coordinated partnerships to increase participation/representation of researchers and communities currently underrepresented in development of AI/ML models. *NIH*

- American Association for the Advancement of Science S&T Policy Fellowship: Provide opportunities to outstanding scientists and engineers to learn first-hand about policymaking while contributing their knowledge and analytical skills to Federal policymaking process. *DHS*

- CISE Minority-Serving Institutions Research Expansion Program: Broaden participation by increasing number of CISE-funded research projects from Minority-Serving Institutions 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*

- Harnessing the Data Revolution (workforce component): Enable new modes of data-driven discovery that will address fundamental questions at frontiers of science and engineering. *NSF*

- Office of Science Early Career Research Program: Support individual research programs of outstanding scientists early in their careers. *DOE/SC*

- Program to empower partnerships with industry and government. *DHS, NSF*

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.

- Administrative Supplements for Workforce Development at the Interface of Information Sciences, AI/ML, and Biomedical Sciences: Support development and implementation of curricular or training activities in information science, AI/ML, and biomedical sciences to develop competencies and skills needed to make biomedical data FAIR and AI/ML ready. *NIH*

- AI learning innovations. *DOE, academic partners*
- Big Data Scientist Training Enhancement Program: Provide two-year fellowship program that uses data science to advance research and patient care. *NIH, VA*
- CISE Graduate Fellowships: Increase number of diverse, domestic graduate students pursuing research and innovation careers in computer science, computer engineering, or information science. *NSF*
- Computer Science for All: Provide all U.S. students opportunity to participate in computer science and computational thinking education in their schools at PreK–12 levels. *NSF*
- Future of Work at the Human-Technology Frontier: Respond to challenges and opportunities for future of employment in landscape with rapid social and technological changes. *NSF*
- National Research Council Research Associateship Programs: Provide graduate, postdoctoral, and senior level research opportunities at sponsoring Federal laboratories and affiliated institutions. *DOT, NIST*
- Path to Advancing Novel Data Analytics: Establish flexible platform for conducting advanced analytics, using AI and ML, with goal of enabling innovative research to be stabilized prior to development into reusable analyses. *DOT*
- Program to Empower Partnerships with Industry and Government: Support data faculty members, research scientists, postdocs, and graduate and undergraduate students from across country in working on high-level problems for Federal Government. *DHS*
- Science, Mathematics, and Research for Transformation Scholarship-for-Service Program: Enhance civilian workforce with innovative U.S. scientists, engineers, and researchers. *DoD*
- Talent Education and Assessment Management System: Assess current knowledge level of workforce and provide meaningful feedback to leadership about capabilities and gaps within their ranks. *GSA, HHS, JAIC, VA, academic partners*
- Workforce education, development, and upskilling. *Air Force, DoD, DOE/NNSA, DOE/SC, OSTP/NAIIO*

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.

Participating Agencies: Air Force, Army, Census, DARPA, DHS, DOE/NNSA, DOE/SC, NARA, NASA, NIH, NIST, NOAA, NRO, NSA, NSF, OSD, USGS

3.7.1.1 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.

- CISE Core Programs: Support research and education projects that develop new knowledge in all aspects of computing, communications, information science and engineering, and advanced cyberinfrastructure. *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 Resurgence Initiative (ERI) thrust areas: Mitigate the skyrocketing costs of electronics design, overcome inherent throughput limits of two-dimensional electronics, increase information processing density and efficiency, and revolutionize communications. *DARPA*

- 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*

- Foundations of Emerging Technologies: Support fundamental research in disruptive technologies and models in computing and communication. *NSF*

- Materials Innovation Platform: Accelerate advances in materials research. *NSF*

- Software and Hardware Foundations: Support potentially transformative research in design, verification, operation, utilization, and evaluation of computer hardware/software through novel approaches, robust theories, high-leverage tools, and lasting principles. *NSF*

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

- ERI: Focus on hardware security, overcoming security threats across 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.

4. Facilitate technology transfer and commercialization.

- Embedded Entrepreneurship Initiative: Provide catalytic funding, mentorship, and investor and corporate connections for DARPA researchers. *DARPA*

- ERI: Focus on developing disruptive electronics technologies for dual-use technologies with emphasis on 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*

- Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR): Transform scientific discovery into products and services with commercial potential and/or societal benefit. *NSF*

3.7.1.2 Key Coordination Activities

- 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)*
- Real-Time Machine Learning: Use advanced machine learning algorithms for integrated circuit design. *DARPA, NSF*
- Subcommittee on Microelectronics Leadership: Coordinate Federal activities in support of the CHIPS and Science Act of 2022. *AFRL, ARL, DARPA, DHS, DOC, DoD, DOE/NNSA, DOE/SC, FBI, IARPA, NASA, NIST, NRL, NSA, NSF, ODNI, OMB, OSTP, State*

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: Army, DARPA, DOE/NNSA, DOE/SC, FDA, NASA, Navy, NIH, NIST, NOAA, NSA, NSF, OSD, USGS

The HEC IWG coordinates Federal R&D to advance U.S. leadership in high capability computing (HCC) and tackle some of the most pressing challenges to continued progress in computing capabilities such as extreme heterogeneity, the slowdown of Moore's Law, and energy efficiency.

3.8.1.1 Strategic Priorities and Associated Key Programs

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

1. Research and develop the innovative approaches and technologies that are critical to the delivery of extreme-scale heterogeneous computing systems to increase scientific insight and accelerate new discoveries.

- Advanced architecture exploration and prototype system development; Component technology investigation. *DOE/NNSA*
- Application software modernization; Computing testbed program. *NASA*
- Computational and Data-Enabled Science and Engineering (CDS&E): Identify and capitalize on opportunities for major scientific and engineering breakthroughs through new computational and data-analysis approaches and best practices. *NSF*
- Computing testbed to explore emerging hardware and software stack for heterogeneous systems; Benchmark of emerging architectures. *NRL*

- Exascale Computing Project (ECP): Develop new class of high-performance computing systems whose power will be measured in exaflops (10^{18} floating point operations per second), or a thousand times more powerful than today's petaflop machines. *DOE/NNSA, DOE/SC*

- National COVID Cohort Collaborative: Place electronic health records data into common data model, establishing a resource to understand COVID-19's long-term health impact. *NIH*

- Principles and Practice of Scalable Systems (PPoSS): Fund projects spanning entire hardware/software stack and that lay foundations for sustainable approaches for implementing performant, scalable, and correct and accurate computing applications running on heterogeneous platforms. *NSF*

- Software stack for extreme HPC heterogeneity; Leadership computing facilities; Research of domain-aware AI algorithms, programming tools, and runtime environments to support new AI workflows. *DOE/SC*

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

- Advanced Computing Systems & Services: Adapting to the Rapid Evolution of Science and Engineering Research: Provide advanced cyberinfrastructure capabilities and services in production operations to support full range of computational- and data-intensive research across S&E. *NSF*

- All of Us Research Program: Generate actively learning algorithms to predict human response to different foods, nutrients, and dietary patterns and to advance understanding. *NIH*

- Develop AI-enabled high-performance simulation and computing technologies. *DOE/NNSA*

- Development of software tools or bio-inspired algorithms for neuromorphic computing. *DOE/SC, NIST*

- Expand Science and Technology Research Infrastructure for Discovery, Experimentation, and Sustainability (STRIDES) CloudLab, which provides a cloud-based platform where researchers can experiment and test cloud computing capabilities. *NIH*

- Exploration of integrated high-performance architectures and non-von Neumann architectures. *NRL*

- Microelectronics research. *DOE/SC*

- Research for development of new materials to enable novel computing. *DOE/SC, NIST*

- Research in quantum computing, computer science, networking, testbeds, and/or other quantum technologies. *DOE/NNSA, DOE/SC, NASA, NIST, NSA, NSF*

- Research of neuromorphic devices or computing systems. *DOE/NNSA, DOE/SC, NIST*

- Semiconductor and Future Computing partnership: Help guide research efforts by leaders in academia on the next generation of computing technologies. *NIST, industry partners*

- Training model components. *NASA*

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

- Continued development of programming models to address performance portability for next-generation node architectures. *DOE/SC*

- CSSI: Enable funding opportunities that are flexible and responsive to evolving and emerging needs in cyberinfrastructure. *NSF*

- Earth system modeling; Cloud computing; HCC assimilation. *NASA*

- Exploration of quantification of reproducibility at exascale; Research to identify software abstraction for parallelism targeting high-end heterogenous compute nodes. *NIST*

- Medical Imaging and Data Resource Center: Collaboration of medical imaging organizations to create datasets for future pandemic prediction. *NIH*

- Productivity Enhancement, Technology Transfer, and Training initiative: Optimize critical physics-based and engineering software so scientists and engineers can precisely and efficiently execute scientific calculations on leading-edge supercomputers; demonstrate and mature leading-edge computational technology from academia and industry. *DoD*

3.8.1.2   Key Coordination Activities

- Annual ECP Principal Investigator meeting: Provide collaborative working forum in support of integrated project understanding, team building, and continued progress. *DOE/NNSA, DOE/SC, other agencies, computing technology stakeholders*

- Earth system modeling: Support development of common framework for earth system modeling. *DoD, NASA, NOAA*

- Project 38: Explore vendor-agnostic architectural options. *DOE/NNSA, DOE/SC, NSA*

- Research in cancer and drug discovery: Develop, demonstrate, and disseminate advanced computational capabilities to seek answers to driving scientific questions that increase our understanding of cancer biology, risk identification, pre-clinical screening, and treatment challenges. *DOE/SC, 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: Army, DOE/NNSA, DOE/SC, NASA, Navy, NIH, NIST, NOAA, NSA, NSF, OSD, 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.

3.9.1.1   Strategic Priorities and Associated Key Programs

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

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

- Advanced Computing Systems & Services: Adapting to the Rapid Evolution of Science and Engineering Research: Fund federation of nationally available HPC resources that are technically diverse and intended to enable discoveries at computational scale beyond research of individual or regional academic institutions. *NSF*

- Cloud HPC. *DoD*

- Dedicated High Performance Computing Project Investments: Provide awards to mission-critical projects that cannot be performed at DoD Supercomputing Resource Centers (DSRCs) because of special operational requirements (e.g., classification level above Secret, emerging technologies). *DoD*

- DSRC: Provide high-performance computing resources to DoD scientists and engineers across the Nation. *DoD*

- Expansion of HCC capabilities for research. *NIST*

- High-End Computing Capability Project: Provide world-class high-end computing, storage, and associated services to enable large-scale modeling, simulation, and analysis to achieve successful mission outcomes. *NASA*

- Leadership HCC at computing facilities in Argonne (Polaris, Aurora) and Oak Ridge (Frontier); Phase 2 upgrade of Perlmutter supercomputer at National Energy Research Scientific Computing Center. *DOE/SC*

- Leadership-Class Computing Facility: Provide unique services and resources to enable discoveries in the largest and most computationally intensive science and engineering research frontiers that could not advance otherwise. *NSF*

- Major Research Instrumentation: Increase access to multi-user scientific and engineering instrumentation for research and research training in the Nation's academic institutions and not-for-profit S&E research organizations. *NSF*

- NASA Center for Climate Simulation: Provide high-performance computing for NASA-sponsored scientists and engineers. *NASA*

- National Center for Atmospheric Research-Wyoming Supercomputing Center: Provide scientific community with most cutting-edge technology to better understand Earth. *NSF*

- STRIDES Initiative: Provide access to rich datasets and advanced computational infrastructure, tools, and services. *NIH*

2. Develop algorithms, applications, and supporting software for current and next-generation HCC platforms to maintain and improve the performance of existing codes to support and advance applications vital to the Nation's security and economy and individual well-being.

- CDS&E (algorithms and techniques development component): Identify and capitalize on opportunities for major S&E breakthroughs through new computational and data-analysis approaches and best practices. *NSF*

- Code modernization hackathons; Jupyterhub (web-based) HCC interfaces; Open-source code developments and the use of GitHub to enhance collaboration and to enable community developments; Open-science portals utilizing cloud-computing resources. *NASA*

- Computational Modeling and Analysis program: Advance computational modeling and analysis methods for aerospace propulsion components and systems. *NASA*

- Computational Research and Engineering Acquisition Tools and Environments Program: Provide tools to enhance productivity by providing design and analysis tools to defense community, thus reducing acquisition development and test process cycle. *DoD*

- CSSI (software and data services component): Emphasize integrated cyberinfrastructure services, quantitative metrics with targets for delivery and usage of these services, and community creation. *NSF*

- Development of algorithms, modeling tools, and computation methods for science applications. *NIST*

- Development of high-throughput AI classification algorithms for detecting COVID-19 in computerized tomography scans. *NIH*

- DoD software applications. *DoD*

- Efforts in ECP algorithms and applications development; Scientific Discovery through Advanced Computing (SciDAC) partnerships; Development and support of software sustainability/stewardship on modern computing platforms. *DOE/SC*

- PPoSS: Fund projects spanning entire hardware/software stack that lay foundations for sustainable approaches for implementing performant, scalable, and correct and accurate computing applications running on heterogeneous platforms. *NSF*

3. Develop resources and tools to lower barriers to HCC access, improve usability, and support collaborations as means to increase productivity and impact.

- Advanced Cyberinfrastructure Coordination Ecosystem: Services & Support: Establish suite of cyberinfrastructure coordination services to support broad and diverse set of requirements, users, and usage modes from all areas of S&E research and education. *NSF*

- Campus Cyberinfrastructure: Invest in specific areas that have emerged as challenges and opportunities in coordinated campus and regional cyberinfrastructure resources in support of science applications and distributed research projects. *NSF*

- Cloud interface. *DoD*

- Development of web-based HPC application interfaces; Consolidation of code repositories; Support of open source code development and GitHub to enhance collaboration and community development. *NASA*

- ECP software technologies, including software development kits. *DOE/SC*

- Extreme Science and Engineering Discovery Environment (XSEDE): Provide single virtual system for scientists to interactively share computing resources, data, and expertise. *NSF*

- HPC Portal Initiative: Provide secure unified access point with single sign-on, support integrated framework with access to de-centralized components, and provide web or web-like centralized interface requiring no software installation on user workstations that will work across multiple security enclaves. *DoD*

- Open Platform for Online Simulations for Stimulating Peripheral Activity to Relieve Conditions: Establish comprehensive, intuitive, freely accessible online platform for Stimulating Peripheral Activity to Relieve Conditions program to use to simulate and study nerve electrophysiology and its interaction with organ physiology. *NIH*

- Partnership to Advance Throughput Computing: Increase national return on investment of compute resources by enabling institutions to share computing capacity, maximizing utilization and giving smaller campuses easier access to this vital capacity. *NSF*

- Psychiatric Cell Map Initiative: Partner with academia to map physical and genetic underlying disorders such as autism spectrum disorders, Tourette disorder, epilepsy, intellectual disability, and schizophrenia to provide key resource for precision medicine. *NIH, academia*

- Structure and Function of a Cubic Millimeter of Cortex: Create online community that makes scientific discoveries about cortical structure and function by reconstructing and analyzing connections between neurons in cubic millimeter of mouse cortex along with activity of same neurons. *NIH*

- Whole-Brain Transcriptome Atlas. *NIH*

4. Develop and provide an HCC ecosystem to a diverse user community, including facilities and resources, and enhance the infrastructure and ecosystem needed to support U.S. leadership in S&E.

- DoD ecosystem. *DoD*

- Interoperable data ecosystem; Federating NIH cloud-enabled data platforms. *NIH*

- NASA computing services. *NASA*

- Operations and upgrades at the leadership computing facilities. *DOE/SC*

- XSEDE (advanced computing, storage, visualization, and data services component): Develop comprehensive advanced digital services cyberinfrastructure to enable transformative open S&E research and innovative training and educational programs, and enable users to advance and share knowledge across domains. *NSF*

5. Develop the current and future HEC workforce for both R&D and infrastructure and application. *See the EdW PCA.*

3.9.1.2 Key Coordination Activities

- Earth System Prediction Capability Working Group: Participate in multi-agency modeling projects. *DoD, DOE, NASA, NOAA, NSF, other agencies*
- HCC resources: Provide and support systems and resources necessary for effective use of HCC systems. *DoD, DOE/SC, NASA, NIH, NSF*
- NCI-DOE collaboration on Joint Design of Advanced Computing Solutions for Cancer: Announced as part of the Cancer Moonshot initiative, addresses critical needs in computing, data transfer, and data management in cancer research. *DOE/NNSA, DOE/SC, NIH*

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, Air Force, Army, DHS, DoD CIO, DOE/AITO, DOJ (NIJ), DTRA, FAA, JAIC, MDA, NASA, Navy, NIH, NIOSH, NIST, NMIO, NRC, NRL, NSF, OSD (OUSD(R&E)), OSHA, TRMC, USDA-NIFA, 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.

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.

- Advance human-robot teaming for space exploration. *NASA*
- Assured DevSecOps of Autonomous Systems portfolio pathfinder. *Air Force, Army, DoD CIO, JAIC, Navy, OUSD(R&E), TRMC, USSF*
- 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. *TRMC*
- Bioengineering Research partnerships. *NIH*
- Early Career Faculty program. *NASA*
- Engineering for Agricultural Production Systems program. *USDA-NIFA*

- Future of Work at the Human-Technology Frontier: Respond to challenges and opportunities for future of jobs and workers in landscape with rapid social and technological changes. *NSF*

- Human-Centered Computing: Support research to design computing systems to amplify humans' physical, cognitive, and social capabilities to accomplish individual and collective goals; assess benefits, effects, and risks of computing systems; and understand how human, technical, and contextual aspects of systems interact to shape those effects. *NSF*

- Mind, Machine, and Motor Nexus: Support fundamental research at the intersection of mind, machine and motor. *NSF*

- Operational trust in mission autonomy. *OUSD(R&E), academic/industry partners*

- Performance of Human-Robot Interaction: Provide methods, protocols, and metrics necessary to evaluate interactive and teaming capabilities of robot systems. *NIST*

- Research evaluating risk factors with robot-related injuries; Intervention research to improve safety around robots; Research into human-robot collaboration. *NIOSH*

- Sonomyographic Upper Limb Prosthetics: A New Paradigm: Develop and test compact research-grade sonomyographic prosthetic system. *NIH*

- Specialty Crop Research Initiative: Promote collaboration, open communication, exchange of information, and development of resources that accelerate application of scientific discovery and technology to solving needs of various specialty crop industries. *USDA-NIFA*

- University Leadership Initiative: Effective Human-Robot Teaming to Advance Aviation Manufacturing: Provide opportunity for U.S. university community to receive NASA funding and take the lead in building their own teams and setting their own research agenda with goals that support and complement NASA aeronautics research goals. *NASA*

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.

- CPS for agriculture. *NSF, USDA-NIFA*

- Dynamics, Control and Systems Diagnostics: Support fundamental research on analysis, measurement, monitoring, and control of dynamic systems. *NSF*

- 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, TRMC*

- Foundational Research in Robotics: Support research on robotic systems that exhibit significant levels of both computational capability and physical complexity. *NSF*

- Game changing development. *NASA*

- 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*

- Helping to End Addiction Long-term® (HEAL) Initiative: Accelerate scientific discovery and develop solutions to address national opioid public health crisis; Technology Research Site for Advanced, Faster Quantitative Imaging for Back Pain Consortium: Develop imaging technology that uses machine learning to make automated assessments of spine characteristics, pain response, and patient-reported outcomes in people with chronic low back pain. *NIH*

- Human-Machine Teaming project: Focus design decisions on explicit allocation of cognitive functions and responsibilities between human and computer to achieve specific capabilities. *MDA*

- Image classifier evaluation technology. *Army, DOT, JAIC, Navy*

- Manufacturing Robotics Testbed: Resource for research in robotics for advanced manufacturing and material handling. *NIST*

- Mobility Performance of Robotic Systems: Provide measurement science to develop standard test methods for intelligent industrial mobility systems. *NIST*

- Model intelligent machines in complex environments. *DoD, industry partners*

- Multi-robot coordination for planetary exploration. *NASA*

- NASA Innovative Advanced Concepts: Support early-stage studies of visionary concepts that could one day "change the possible" in space and aeronautics. *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*

- Robust Intelligence: Understand and develop systems that can sense, learn, reason, communicate, and act; exhibit flexibility, resourcefulness, creativity, real-time responsiveness, and long-term reflection; use variety of representation or reasoning approaches; and demonstrate competence in complex environments and social contexts. *NSF*

- Safety standards, certifications, and regulations; Robot-related workplace fatalities and injury surveillance. *NIOSH*

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

- 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*

- Emerging Frontiers in Research and Innovation: Brain-Inspired Dynamics for Engineering Energy-Efficient Circuits and Artificial Intelligence: Create new engineering science of brain-inspired engineered learning systems. *AFOSR, DTRA, NASA, NSF*

- Measurement science, standards, and test methods for soft robotics. *NIST*

- Robotics research, safety benefits, and risks with powered exoskeletons. *NIOSH*

- Smart Health and Biomedical Research in the Era of Artificial Intelligence 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*
- STTR Soft Robotic Manipulators with Enhanced Perception Using Multimodal Sensory Skins: Transfer promising technology of elastomeric sensors into commercial products. *NASA, academic partner*
- Wearable sensors for biofeedback and remote monitoring. *NIH*

4. Improve resilience in robotics: (a) to respond to failures or incomplete or corrupted information; and (b) to assist in national response to critical and unexpected events.

- 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 (NSF SBIR and STTR program): Foster innovation in robotic applications in healthcare and next-generation automation, and help create U.S. businesses and jobs. *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 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 such as Europa and Enceladus. *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*
- SBIR, Program 8.13: Plant Production and Protection (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. *USDA-NIFA*
- Smart deep space habitat. *NASA*

5. Promote ethical standards and broader participation in robotics.

- Evaluation of training and psychosocial impact of workplace displacement; Occupational robotics research education. *NIOSH*
- NASA Space Technology graduate research opportunities. *NASA*

- NSF Research Traineeship Program: Develop ways for graduate students in research-based degree programs to develop skills, knowledge, and competencies needed to pursue STEM careers. *NSF*

- Research on Emerging Technologies for Teaching and Learning: Fund exploratory and synergistic research in emerging technologies (including AI, robotics, and immersive or augmenting technologies) for future teaching and learning. *NSF*

- Robot-Assisted Cognitive Training for Socially Isolated Older Adults with Mild Cognitive Impairment: Develop socially assistive robot to provide cognitive training to improve cognitive functioning and reduce feelings of loneliness in socially isolated older adults. *NIH*

- Social Assistive Robot Interface for People with Alzheimer's and Other Dementias to Aid in Care Management: Develop socially assistive robot system for persons with dementia (mild cognitive impairment, Alzheimer's disease, or other dementias) in assisted living facilities. *NIH*

- Space Technology announcement of collaboration opportunity. *NASA, SBIR/STTR*

- Tools for Collaborative Robots within Small and Medium Enterprise 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

- Advanced Robotics for Manufacturing Institute: Develop open-source, interoperable performance metrics and test methods. *Air Force, Army, NASA, Navy, NIOSH, NIST, academic/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. ANSI, DHS, DOI, FAA, NASA, NIOSH, NIST*

- IEEE 1872.2 Autonomous Robotics Ontology Working Group: Represent more specific concepts and axioms that are commonly used in autonomous robotics. *NASA, NIST, academic/industry partners*

- 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*

- 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/industry partners*

- Lunar Surface Innovation Consortium: Advance lunar surface exploration. *NASA, academic/industry partners*

- Metrics, Evaluation, and Software Infrastructure: Develop open source metrics, performance test methods, and interoperability. *Air Force, Army, Navy, NIST, industry partners*

- 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*

- MURI: Support research teams for which research efforts intersect more than one traditional science and engineering discipline. *DoD, academic partners*

- NASA Jet Propulsion Laboratory: Advance robotics technologies for search and rescue in underground environments. *NASA, NIOSH*

- Principal Investigator meetings: Review research, identify new applications, and discuss S&T gaps and barriers. *AFOSR, DHS, DOE/AITO, DOT, NASA, Navy, NIH, NIOSH, NIST, NSA, NSF, ONR, USDA-NIFA*

- 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/set terminology, safety, and performance standards for robots, industrial vehicles, exoskeletons, mobile manipulators, etc. *DHS, DOE/AITO, DOI, DOJ, FAA, NIH, NIOSH, NIST, NRC, NRL, OSHA, State*

- Space Trusted Autonomy: Identify and prioritize development of self-sustaining and reliable technologies that are certified for mission use. *NASA, NRO, USSF*

- Trust in autonomous systems: Provide applications, algorithms, views, diagnostics, and other solutions to monitor, report and increase autonomous system trustworthiness. *DHS, DoD, DOJ, DOT, industry partners*

- International collaborations:
  - TCSC Autonomy and AI Working Group: Work bilaterally with ROK on cyber and drone defense, autonomous situation awareness, scalable teaming, unmanned ground robots. *DoD Service Labs, ROK Agency for Defense Development, OUSD(R&E)*
  - U.S./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. *Defence Science and Technology Laboratory (UK), DoD Service Labs, OUSD(R&E)*

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: Air Force, Army, Census, DARPA, DHS, DOE/NNSA, DOE/SC, NASA, NIH, NIST, NOAA, NRO, NSF, OSD, USGS

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, data science capabilities to accelerate scientific discovery and innovation, providing the foundation for algorithm-driven businesses and catalyzing innovations critical to the Nation.

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.

- CDS&E: Identify and capitalize on opportunities for major scientific and engineering breakthroughs through new computational and data-analysis approaches and best practices. *NSF*

- Foundational research in storage systems and input/output, data visualization, and codesign of AI/ML technologies with data models, applications, and bio-preparedness research virtual environment. *DOE/SC*

- HEAL Initiative: Accelerate research and speed scientific solutions to stem national opioid public health crisis. *NIH*

- Innovative Tools and Methodologies programs in various NSF Directorates. *NSF*

- Permissioned blockchains. *DHS, NIST, NSF*

- PPoSS: Fund projects spanning entire hardware/software stack and that lay foundations for sustainable approaches for implementing performant, scalable, and correct and accurate computing applications running on heterogeneous platforms. *NSF*

- Precision Interventions for Severe and/or Exacerbation-prone Asthma Network: Conduct phase II/proof-of-concept clinical trials of precision interventions in population with severe asthma. *NIH*

- Transdisciplinary Research in Principles of Data Science: Bring together statistics, mathematics, and theoretical computer science communities to develop theoretical foundations of data science through integrated research and training activities. *NSF*

2. Advance the trustworthiness, reliability, accuracy, performance, generalizability, and ethical integrity of data-driven discovery and decision making to better support innovation in S&T and the industries of the future.

- Alzheimer's Disease & Related Dementias: Conduct research leading to development of innovative products and/or services that may advance progress in preventing and treating Alzheimer's disease and Alzheimer's disease-related dementias. *NIH*

- Childhood Cancer Data Initiative: Enhancing data sharing to improve understanding of cancer biology to improve preventive measures, treatment, quality of life, and survivorship and to ensure that researchers learn from every child with cancer. *NIH*

- Data quality standards development. *NIST*
- Fundamental research into federated learning, explainable AI, and scientific machine learning. *DOE/SC*
- Harnessing the Data Revolution: Institutes for Data-Intensive Research in Science and Engineering: Perform data-intensive research in science and engineering that can accelerate discovery and innovation in broad array of research domains. *NSF*
- National AI Research Institutes (data aspects). *NIST, NSF, OSD, USDA, other agencies*
- Secure and Trustworthy Cyberspace Program: Protect and preserve growing social and economic benefits of cyber systems while ensuring security and privacy. *NSF*

3. Facilitate the discoverability, interoperability, and reusability of diverse data that are scalable and agile enough to meet the needs of innovation.

- Big Data Governance and Metadata Management framework development: Enable data integration/mashup among heterogeneous datasets from diversified domain repositories and make data discoverable, accessible, and usable through machine-readable and actionable standard data infrastructure. *NIST, other agencies*
- Common Fund Data Ecosystem: Develop portal that will allow researchers to access and work across multiple Common Fund program datasets within digital cloud environment. *NIH*
- CSSI (interoperability and reuse of data): Enable funding opportunities that are flexible and responsive to evolving and emerging needs in cyberinfrastructure. *NSF*
- Cyberinfrastructure for Emerging Science and Engineering Research: Catalyze new science and engineering discovery pathways through early-stage collaborative activities between disciplinary scientists and engineers and developers/implementers of innovative cyberinfrastructure capabilities, services, and approaches. *NSF*
- EarthCube: Create well connected and facile environment to share data and knowledge for all geosciences in open, transparent, and inclusive manner and to accelerate ability to understand and predict Earth. *NSF*
- FAIR Data and Models for Artificial Intelligence and Machine Learning: Make data and models reusable by AI application developers and researchers through attention to FAIR Data Principles. *DOE/SC, NIH*
- PubMed Central Article Datasets in the Amazon Web Services (AWS) Cloud: Enhance machine access to biomedical literature and drive impactful analyses and reuse. *NIH*
- Rapid deployment R&D capabilities. *DHS*

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

- Co-design data analysis and reuse at scientific user facilities; Foundational research in data reduction. *DOE/SC*
- CISA Advanced Analytics Platform for Machine Learning: Offer multi-cloud environment where new tools and software can be researched and tested against live data. *DHS*

- Exploration of real-time, machine-actionable, and composable analytics as scalable and federated services. *NIST*

- Harnessing the Data Revolution: Enable new modes of data-driven discovery that will address fundamental questions in S&E. *NSF*

- Integrated Research Institute: Accelerate research in environmental and materials science via diverse collection of on-demand scientific data processing tasks and computationally intensive simulations. *DOE/SC*

- Mine real-time social media big data to monitor human immunodeficiency virus. *NIH*

- Real-time analytics for multi-latency. *DHS*

- Real-Time Machine Learning: Explore high-performance, energy-efficient hardware and ML architectures that can learn from continuous stream of new data in real time. *NSF*

5. Build the current and next generation workforce necessary to develop, support, and use all aspects of big data. *See the EdW PCA.*

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

- Convergence Accelerator (focus on transitioning basic research and discovery into practice): Fund teams to solve societal challenges through convergence research and innovation. *NSF*

- National COVID Cohort Collaborative: Maintain one of the largest collections of clinical data related to COVID-19 symptoms and patient outcomes in the United States. *NIH*

- Public Access Initiative: Make the outputs of NSF-funded research publicly available to the greatest extent, with the fewest constraints possible, and consistent with law. *NSF*

- Rapid deployment of R&D capabilities. *DHS*

- SBIR: Complex Data. *DOE/SC*

- SciDAC partnerships; Software sustainability; International standards. *DOE/SC*

3.11.1.2 Key Coordination Activities

- Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) Sequencing for Public Health Emergency Response, Epidemiology, and Surveillance: Coordinate SARS-CoV-2 sequencing, including accelerated data generation and the sharing and rapid release of high-quality viral sequence data from clinical and public health laboratories. *Army, FDA, NIH, NSF, USDA, other agencies, other public health and scientific communities*

- Subcommittee on Open Science: Participate in interagency coordination of policy around data management and open science. *BD IWG agencies, other agencies*

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, Air Force, Army, BLS, CDC, DARPA, DHS, DOE/SC, DOJ (NIJ), FAA, FDA, GSA, IARPA, NASA, Navy, NIH, NIST, NOAA, NRC, NSA, NSF, NTIA, ONC, ONR, OSD

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.

- Bugs Framework: Provide a structured, complete, orthogonal, and language-independent classification of software weaknesses. *NIST*

- Building trusted and resilient systems. *AFRL*

- Combinatorial testing: Explore methods for more effective and less expensive software testing. *NASA, NIST*

- Designing Accountable Software Systems: Understanding relationship between software systems and complex social and legal contexts within which they operate to jointly develop rigorous and reproducible methodologies for understanding the drivers of social goals for software and for designing, implementing, and validating. *NSF*

- 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*

- Independent Verification and Validation Program Software Assurance Research Program: Provide NASA with greater knowledge about the software assurance practices, methods, and tools needed to produce safe and reliable software. *NASA*

- Legacy system refurbishment. *ONR*

- Roots of Trust: Provide highly reliable hardware, firmware, and software components that perform specific, critical security functions. *DoD, NIST*

- 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*

- Software Assurance Metrics and Tool Evaluation: Develop metrics for the effectiveness of software security assessment tools, and assess current methods and tools in order to identify deficiencies which can lead to software product failures and vulnerabilities. *Census, DARPA, IARPA, NIST, NSA*

- Total platform cyber protection. *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.

- Applied category theory. *NASA, NIST*

- Automated vulnerability identification prioritization for embedded resources. *AFRL*

- Root- and rule-based techniques. *NIST*

- Secure and Trustworthy Cyberspace: Protect and preserve the growing social and economic benefits of cyber systems while ensuring security and privacy. *NSF*

- Software abstractions for parallel architectures. *DoD, NIH, NIST*

- Software Engineering for Novel Architectures: Ensure that NOAA's model suite is ready for future HPC systems, including supporting standards activities, porting codes to fine-grain architectures, examining programming methods, and addressing alternative algorithms and general approaches to solving environmental modeling problems. *DOE/SC, NOAA*

- System-Wide Safety Project: Perform high-risk R&D with focus on exploring, discovering, and understanding the impact on safety from technical advancements in aviation and any associated emerging operations. *AFRL, DoD, FAA, NASA, industry partners*

- Trojans in Artificial Intelligence: Combat Trojan attacks by inspecting AIs for Trojans. *IARPA, NIST*

- Web Image Processing Pipelines: Lower the bar 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*

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.*

3.12.1.2 Key Coordination Activities

- Earth System Prediction Capability: Coordinate across the Federal environmental research and operational prediction communities to improve global prediction, including by identifying hardware and software challenges and R&D needs. *Air Force, DOE/SC, NASA, Navy, NOAA, NSF*

- Joint Federated Assurance Center: Support robust, secure software development. *Air Force*

- International collaborations:

  ◦ Global Alliance for Genomics and Health: Work with global members in developing data-sharing standards in genomics and healthcare, and provide research funding for essential software components. *NIH, global partners*

4.0 Other NITRD Interagency Coordination Activities

4.1 Digital Health R&D (DHRD) IWG[31]

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.

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

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 health IT 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.

- AIM-AHEAD: Establish mutually beneficial and coordinated partnerships to increase the participation/representation of researchers and communities currently underrepresented in the development of AI/ML models. *NIH*

- Care Transition grants; Digital healthcare safety grants. *AHRQ*

- Clinical Decision Support (CDS) Initiative: Improve healthcare delivery by enhancing medical decisions with targeted clinical knowledge, patient information, and other health information. *AHRQ, CDC, CMS, FDA, NIH, ONC, VA*

- Developing Digital Therapeutics for Substance Use Disorders: Accelerate the development of digital therapeutics to treat substance use disorders. *NIH*

- Digital Healthcare Equity Framework With an Accompanying Guide for Its Use: Improve healthcare delivery and outcomes by reducing health inequities that can result from the use of digital technologies. *AHRQ*

- Integrating Patient-Generated Digital Health Data into Electronic Health Records in Ambulatory Care Settings: An Environmental Scan and a Guide: Advance the integration and use of patient-generated digital health data in ambulatory care settings. *AHRQ*

- Internet of Things in healthcare; NextGen magnetic resonance imaging; Imaging for NextG instruments and therapies. *NIST*

- Smart Health and 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*

---

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

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.

- Center for Evidence and Practice Improvement Evidence Discovery and Retrieval Project: Make PCOR findings within AHRQ repositories more FAIR through technologies used by clinicians, researchers, implementers, patients, and others. *AHRQ*

- Convergence Accelerator: Fund teams to solve societal challenges and to provide capability to operate securely within communications infrastructures with focus on urban flooding, judicial court records, biomedical health, geospatial information, and technology infrastructure for knowledge network creation and use. *NSF*

- Data at rest quality management tool; Fast Healthcare Interoperability Resources Toolkit. *NIH, NIST*

- 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*

- Evidence-based Care Transformation Support: Inform requirements to achieve evidence-based care transformation via an improved digital knowledge ecosystem for use by AHRQ and dozens of other public and private organizations. *AHRQ*

- 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. *AHRQ, CMS, NIH, ONC, VA*

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

- NIH Policy for Data Management and Sharing. *NIH*

- Research Collaboratory for Structural Biology Protein Data Bank: Build upon Protein Data Bank data by creating tools and resources for research and education in molecular biology, structural biology, computational biology, and beyond. *DOE, NIH, NSF*

- Testing claim-based indicators of frailty and functional disabilities in electronic health record data. *AHRQ, NIH, ONC*

3. Support the integration and 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.

- Display optical metrology. *NIST*

- Moving Toward Semantic Interoperability of Medical Devices research. *NIST*

- Pandemic Research for Preparedness and Resilience Virtual Organization: Facilitate the collection and sharing of datasets, software tools, and documentation relevant to the pandemic research community; identify new research gaps and synergies; and create a research roadmap that identifies multidisciplinary research directions to prepare for and recover from future pandemics. *NSF*

- Predictive Intelligence for Pandemic Prevention: Better understand the dynamic nature of pathogen and disease emergence, which poses a continuing risk to our national security, health, and economic stability. *NSF*

- Rapid Acceleration of Diagnostics (RADx) programs: Speed innovation in the development, commercialization, and implementation of technologies for COVID-19 testing. *BARDA, CDC, FDA, NIH*

- Service-Ready Tools for Identification, Prevention, and Treatment of Individuals at Risk for Suicide: Support the development and testing of optimized, service-ready tools to enhance suicide prevention by improving the identification and treatment of individuals at risk for suicide. *NIH*

- 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 the healthcare system's 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 IT R&D of products that improve health and expand the U.S. bioeconomy.

- Adaptive, Sustainable Health Regional Innovation Engine networks. *NSF*

- Centers on Telehealth Research for Cancer-Related Care: Fund clinical trials dedicated to advancing a national telehealth research agenda focused on improving cancer-related care and outcomes across the cancer control continuum in a rapidly changing healthcare, policy, technology, and communication environment. *NIH*

- ClinicalTrials.gov modernization effort. *NIH*

- Improving Rural Health Through Telehealth-Guided Provider-to-Provider Communication Pathways to Prevention: Identify research gaps, explore barriers and facilitate sustainable implementation of provider-to-provider telehealth in rural settings. *AHRQ, CDC, NIH*

- Tools for searching the COVID-19 dataset; Smart healthcare. *NIST*

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 healthcare delivery organization-managed telehealth solution. *NIST*

- Provide education and training opportunities to build the diverse, highly skilled, geographically distributed, and interdisciplinary health IT workforce of the future. *See the EdW PCA*

- Securing Picture Archiving and Communication System: Cybersecurity for the Healthcare Sector: Centralize functions surrounding medical imaging workflows and serve as an authoritative repository of medical image information. *NIST*

- Securing Telehealth Remote Patient Monitoring Ecosystem: Cybersecurity for the Healthcare Sector: Provide a practical solution for securing the telehealth remote patient monitoring ecosystem. *NIST*

- 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 AI in healthcare. *All DHRD agencies*

- BIO+AI Community of Practice: Establish best practices for sharing data and making it AI accessible. *DOC, DoD, DOE, NASA, NIST, NSF, USDA*

- Coordinate the health-IT related response to the COVID-19 pandemic. *All DHRD agencies*

- Cyber-Physical Systems: Enable capability, adaptability, scalability, resiliency, safety, security, and usability that will expand the horizons of critical systems. *NIH, NSF*

- Cybersecurity, Privacy, and Ethics in Biomedical Research: Workshop held in 2021 to bring together these disparate research communities. The report is scheduled for release in 2022. *NIH, NSF*

- Health IT Advisory Committee: Recommend policies, standards, implementation specifications, and certification criteria relating to the implementation of a health IT infrastructure, nationally and locally. *CDC, FDA, NIH, NIST, VA*

- Implement the *2020–2025 Federal Health IT Strategic Plan*:[32] 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*

- mPower Workgroup: Examine and discuss the state of science in mobile and sensing technologies. *FDA, HRSA, NIH, NSF*

- NIH-NSF interagency solicitations: Smart and Connected Health: Accelerate development and use of next-generation healthcare solutions. *NIH, NSF*

4.2   Information Integrity R&D (IIRD) IWG

NITRD launched the IIRD IWG in July 2021. Its purpose is to provide a forum for interagency coordination on R&D investments in information integrity. Specifically, the IIRD IWG identifies research gaps, defines future research directions, enables opportunities for interagency collaborations and investments, encourages public-private partnerships, and disseminates research results. The IWG is currently drafting a Federal information integrity R&D strategic plan.

---

[32] https://www.healthit.gov/topic/2020-2025-federal-health-it-strategic-plan

Federal agencies are spearheading the Science and Technology of Information Integrity to detect information manipulation and the spread of misinformation, and to identify sources, causes, and harms to individuals and society; evidence-based strategies to prevent and mitigate information manipulation; system design for resilience to information manipulation; and pedagogical methods to enable critical thinking and informed citizens.

Participating Agencies: CIA, DARPA, DHS, DOE, FBI, NASA, NIST, NOAA, NSF, ODNI, State, USAID

4.2.1 Strategic Priorities and Associated Key Programs

The priorities for Federal information integrity R&D will be detailed in the upcoming Federal information integrity R&D strategic plan.

4.2.2 Key Coordination Activities

The coordination activities for advancing information integrity R&D and the strategic plan will be reassessed and established in conjunction with the strategic plan.

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, including, but not limited to, health, education, manufacturing, agriculture, security, energy, and environment. NAIIA calls for NSF to lead Federal agencies in providing investments to jump-start these innovations through National AI Research Institutes ("AI Research 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 translate the research into products, applications, and services.

The NAIIA requires, among other provisions, that the AI Research 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. AI Research Institutes address multiple AI R&D themes, and the Institutes' numerous partners are located in 40 states and several countries.

This section serves as the FY 2023 annual report on the status of the AI Institutes as called for in the National Artificial Intelligence Initiative Act of 2020. The following subsections provide an overview of NSF-led and other AI Research Institutes launched to date. Tables 2.1-3 and 2.1-4 in Section 2.0 provide the actual, enacted, and requested investments by Federal agencies for both NSF-led and other agencies' AI Research Institutes for FYs 2021–2023.

5.2 NSF-Led AI Research Institutes, by R&D Theme

In partnership with several other agencies, NSF established five initial AI Research Institutes in 2020 spanning five research themes with a projected investment over five years of approximately $20 million each in planned partnerships with several other Federal agencies. In 2021, NSF partnered with other Federal agencies and private sector organizations to establish nine additional AI Research Institutes spanning six research themes, also at about $20 million over five years. Institute themes span both fundamental AI R&D and R&D for AI-driven innovation in specific domains. Through a joint program with NSF, USDA-NIFA established two AI Research Institutes each in 2020 and 2021 addressing AI-driven innovation in agriculture and the food system, with similar investments, bringing the total number of AI Research Institutes to 18. Grouped by R&D themes, the following subsections provide summary descriptions of NSF-led AI Research Institutes, along with AI Research Institute focus areas; funding levels; and lists of leading and participating institutions, private partners, and collaborators as of January 2022. FY 2023 AI Research Institute awards are scheduled to be made post publication. For updates on AI Research Institute awards, visit https://www.nsf.gov/cise/ai.jsp.

5.2.1 *Theme: AI in Computer and Network Systems*

5.2.1.1 **AI Institute for Edge Computing Leveraging Next-Generation Networks (also known as Athena).** *DHS, NSF*

Year Launched	2021		
Focus	Develop 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.		
Funding	For information on funding, please see https://www.nsf.gov/awardsearch/showAward?AWD_ID=2112562.	**Primary Organization**	Duke University

Other Principal Organizations		
• Massachusetts Institute of Technology (MIT)	• Princeton University	• University of Wisconsin-Madison
• North Carolina A&T State University	• University of Michigan	• Yale University

Partners/Collaborators		
• 5NINES	• Microsoft	• Town of Cary, NC
• AT&T	• Motorola Solutions	• The STEM Early College at North Carolina A&T State University
• Edge Micro	• North Carolina School of Science and Mathematics	

More information	https://athena.duke.edu/

5.2.1.2 **AI Institute for Future Edge Networks and Distributed Intelligence (AI-EDGE).** *DHS, NSF*

Year Launched	2021		
Focus	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 healthcare, 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.		
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 Texas at Austin
• Northeastern University	• University of Massachusetts Amherst	• University of Washington
• Purdue University	• University of Michigan	• University of Wisconsin-Madison
• University of Illinois Chicago		

Partners/Collaborators		
• Air Force Research Laboratory (NY)	• AT&T Labs	• Naval Research Laboratory
• Air Force Research Laboratory (OH)	• IBM Watson Research Center	• Qualcomm (CA)
• Army Research Laboratory	• Microsoft	• Qualcomm (NJ)
More information	https://aiedge.osu.edu/	

5.2.2 *Theme: AI for Advances in Optimization*

5.2.2.1 AI Institute for Advances in Optimization (AI4Opt). *NSF, Industry Partners*

Year Launched	2021		
Focus	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.		
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 Berkeley	• University of Texas at Arlington
• Spelman College	• University of Southern California	

Partners/Collaborators		
• Amazon Robotics	• Girls Academic Leadership Academy	• Midcontinent Independent Systems Operator
• Atlanta Public Schools	• Gurobi Optimization	• Oak Ridge National Laboratory
• Georgia Center of Innovation for Logistics	• Lawrence Livermore National Laboratory	• Ryder
• Georgia Dept. of Economic Development	• Los Alamos National Laboratory	• UPS
More information	https://www.ai4opt.org/	

5.2.2.2 AI Institute for Learning-Enabled Optimization at Scale (TILOS). *NSF, Industry Partners*

Year Launched	2021		
Focus	Aim 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.		
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		
• MIT	• University of Pennsylvania	• Yale University
• National University	• University of Texas at Austin	

Partners/Collaborators		
• A Reason to Survive	• Girl Scouts San Diego	• Samsung Strategy and Innovation Center
• Allen Institute for Artificial Intelligence	• IBM	• Silicon Integration Initiative, Inc.
• Ansys, Inc.	• Mentor Graphics (Siemens)	• Sweetwater Union High School District
• Arm, Ltd.	• Microsoft	• Synopsis, Inc.
• Brain Corporation	• Nvidia Corporation	• TuSimple, Inc.
• Cadence Design Systems	• Planck Aerosystems, Inc.	• Western Digital CHIPS Alliance
• Facebook	• SACNAS	• XiLinx, Inc.
• FIRST	• Samsung Austin R&D Center, TX	

More information	https://tilos.ai/

5.2.3 *Theme: AI and Advanced Cyberinfrastructure*

5.2.3.1 **AI Institute for Intelligent Cyberinfrastructure with Computational Learning in the Environment (ICICLE).** *NSF*

Year Launched	2021		
Focus	Build the next generation of cyberinfrastructure that will make AI easy for scientists to use and promote its further democratization. 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		
• Case Western Reserve University	• Rensselaer Polytechnic Institute	• University of California San Diego
• IC-FOODS	• San Diego Supercomputer Center	• University of Delaware
• Indiana University	• Texas Advanced Computing Center	• University of Utah
• Iowa State University	• University of California Davis	• University of Wisconsin-Madison
• Ohio Supercomputer Center		

Partners/Collaborators		
• AccessComputing	• Indiana University, Jetstream	• Princeton University
• Agricultural Data Coalition	• Information Sciences Institute	• Science Gateways Community Institute
• AI Institutes: AIFARMS, AIFS	• Lawrence Livermore National Laboratory	• Southern California Earthquake Center
• Brookhaven National Laboratory	• Max Planck Institute	• The Findings Group
• CNH Industrial	• Microsoft AI for Earth	• Trusted CI Institute
• Computing Alliance of Hispanic-Serving Institutions	• Mid-Ohio Food Collective	• U.S. Fish and Wildlife Service
• Expanding Pathways in Computing Alliance	• Molecular Sciences Software Institute	• University of North Carolina at Chapel Hill
• Fermi National Accelerator Laboratory	• National Center for Women and Information Technology	• University of Stuttgart
• I Love Farmers Markets	• National Ecological Observatory Network-Battelle	• WildMe
• IAIFI	• Nationwide Children's Hospital	
More information	https://icicle.osu.edu/	

5.2.4   *Theme: AI-Augmented Learning*

5.2.4.1   **AI Institute for Adult Learning and Online Education (ALOE).** *NSF, Industry Partners*

Year Launched	2021		
Focus	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. Along 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 equitable.		
Funding	For information on funding, please see https://www.nsf.gov/awardsearch/showAward?AWD_ID=2112532.	**Primary Organization**	Georgia Research Alliance
Other Principal Organizations			
• Arizona State University	• Georgia State University	• Technical College System of Georgia	
• Drexel University	• Harvard University	• University of North Carolina at Greensboro	
• Georgia Institute of Technology			
Partners/Collaborators			
• Boeing	• IMS Global		
• IBM	• Wiley		
More information	https://aialoe.org/		

5.2.4.2 AI Institute for Engaged Learning. *NSF*

Year Launched	2021		
Focus	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	• University of North Carolina at Chapel Hill
• Indiana University	• Vanderbilt University

Partners/Collaborators

• AI for Teachers	• EngageCSEdu	• Nextech
• Boys & Girls Clubs of Bloomington	• Greater Clark County Schools	• North Carolina Department of Public Instruction
• Boys & Girls Clubs of the Coastal Plain	• Indiana School for the Deaf	• North Carolina Museum of Natural Sciences
• Code.org	• Loogootee Community Schools	• Pitt County Schools
• Computer Science Teachers Association	• Metro Nashville Public Schools	• STARS Computing Corps
• Computing Research Association	• Metropolitan School District of Wayne Township	• Wake County Public School System
• CSforALL	• Monroe County Community School Corporation	• WonderLab Museum of Science, Health and Technology
• Durham Public Schools		

More information	https://www.aiengage.org/

5.2.4.3 AI Institute for Student-AI Teaming (iSAT). *NSF*

Year Launched	2020		
Focus	Develop groundbreaking AI that helps both students and teachers to work and learn together more effectively, and equitably, while helping educators focus on what they do best: inspiring and teaching students. The vision is to develop engaging "AI partners" that will observe, participate in, and facilitate collaborative STEM learning conversations by interacting naturally through speech, gesture, gaze, and facial expression in real-world classrooms and remote learning settings.		
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

• Brandeis University	• University of California Berkeley	• University of Wisconsin-Madison
• Colorado State University	• University of California Santa Cruz	• Worcester Polytechnic Institute
• Georgia Institute of Technology	• University of Illinois Urbana-Champaign	

Partners/Collaborators

• Curve10	• Project VOYCE	• St. Vrain Valley Schools, CO
• Denver Public Schools	• SparkFun	• The Op Ed Project

More information	https://www.colorado.edu/research/ai-institute/

5.2.5 *Theme: AI-Driven Innovation in Agriculture and the Food System*

5.2.5.1 AI Institute for Agricultural AI for Transforming Workforce and Decision Support (AgAID). *USDA-NIFA*

Year Launched	2021				
Focus	Integrate AI methods into agriculture operations for prediction, decision support, and robotics-enabled agriculture to address complex agricultural challenges. This 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. AgAID involves farmers, workers, managers and policymakers in development of these solutions as well as AI training and education, which promotes equity by increasing the technological skill levels of the next-generation agricultural workforce.				
Funding (in millions)	*FY 2021*	*FY 2022*	*FY 2023*	**Primary Organization**	Washington State University
	4.0	4.0	4.0		

Other Principal Organizations		
• Carnegie Mellon University	• innov8.ag	• University of Virginia
• Heritage University	• Oregon State University	• Wenatchee Valley College
• IBM Research	• University of California Merced	

Partners/Collaborators		
• AgTech Insight	• Leibniz Institute of Agricultural Engineering and Bio-economy	• Verdant Robotics
• Allan Brothers	• Linn-Benton Community College	• Walla Walla County Conservation District
• Almond Board of California	• Merced College	• Washington Department of Ecology
• CA Department of Water Resources	• Merced Irrigation District	• Washington Mint Commission
• Cascadia Innovation Corridor	• Mercer Ranches	• Washington Tree Fruit Commission
• Central Valley Community Foundation	• Microsoft	• Washington Wine Grape Commission
• Chemeketa Community College	• Okanogan Irrigation District	• Wilbur-Ellis
• Columbia Basin College	• Turlock Irrigation District	• Wonderful Orchards
• Environmental Defense Fund	• University of British Columbia	• Yakama Nation Tribal School
• G.S. Long	• University of Technology Sydney	• Zirkle Fruit Company
• Grassland Water District	• Valencia Polytechnic University	

More information	https://agaid.wsu.edu/

Note: For the FY columns, FY 2021 refers to actual budget, FY 2022 refers to planned budget, and FY 2023 refers to budget request.

5.2.5.2 AI Institute for Future Agricultural Resilience, Management, and Sustainability (AIFARMS). *USDA-NIFA*

Year Launched	2020				
Focus	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.				
Funding (in millions)	*FY 2021*	*FY 2022*	*FY 2023*	Primary Organization	University of Illinois Urbana-Champaign
	4.0	4.0	4.0		

Other Principal Organizations	
• Argonne National Laboratory	• Michigan State University
• Danforth Plant Science Center	• Tuskegee University
• Center for Digital Agriculture at the University of Illinois	• University of Chicago
• USDA-ARS	

Partners/Collaborators		
• AGCO Corporation	• EarthSense	• Microsoft
• Agrela™ Ecosystems	• IBM Research	• Strawn Pork
• Benson Hill®	• John Deere	• Syngenta Crop Protection

More information	https://aifarms.illinois.edu/

Note: For the FY columns, FY 2021 refers to actual budget, FY 2022 refers to planned budget, and FY 2023 refers to budget request.

5.2.5.3 AI Institute for Next-Generation Food Systems (AIFS). *USDA-NIFA*

Year Launched	2020				
Focus	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/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.				
Funding (in millions)	*FY 2021*	*FY 2022*	*FY 2023*	Primary Organization	University of California Davis
	4.0	4.0	4.0		

Other Principal Organizations	
• Cornell University	• University of California Berkeley
• University of California Agriculture and Natural Resources	• University of Illinois Urbana-Champaign

Partners/Collaborators		
• ADM Global headquarters	• FoodShot Global	• The Production Board
• AGR Partners	• FTW Ventures	• The Rockefeller Foundation
• BASF	• Mars, Incorporated	• ThermoFisher Scientific
• Better Food Ventures	• MISTA	• Thomas Jefferson Foundation
• Better Ventures	• Novozymes (North American headquarters)	• University of California Davis Plant Breeding Center
• Bow Capital	• Nuritas, Ltd.	
• Culinary Institute of America at Copia	• Process Integration and Predictive Analytics	• University of California Davis Seed Biotechnology Center
• Digestiva	• Sacramento City College	• USDA-ARS
• Farm Foundation	• The March Fund	• West Hills College Coalinga

More information	https://aifs.ucdavis.edu/

Note: For the FY columns, FY 2021 refers to actual budget, FY 2022 refers to planned budget, and FY 2023 refers to budget request.

5.2.5.4 AI Institute for Resilient Agriculture (AIIRA). *USDA-NIFA*

Year Launched	2021				
Focus	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. The institute 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.				
Funding (in millions)	*FY 2021*	*FY 2022*	*FY 2023*	**Primary Organization**	Iowa State University
	4.0	4.0	4.0		

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		

Partners/Collaborators

• Agriculture Genome to Phenome Initiative	• ETALYC, Inc.	• North American Plant Phenotyping Network
• AI Institutes: AIFARMS, AIFS	• Federal Statistical Research Data Center at Iowa State University	• NSF Transdisciplinary Research In Principles Of Data Science Institute at University of Arizona
• Bayer	• Genomes to Fields Initiative	
• Big Data in a Box	• Grow Pittsburgh	• Oak Ridge National Laboratory
• BioConnect Iowa	• International Plant Phenotyping Network	• Omni Analytics Group
• Bloomfield Robotics	• Iowa Corn Growers Association	• Practical Farmers of Iowa
• Cornell AgriTech (NY State Agricultural Experiment Station)	• Iowa Economic Development Authority	• Raven Applied Technology
• Corteva Agriscience	• Iowa Fruit and Vegetable Growers Assn.	• RocketML, Inc.
• CSIRO, Australia	• Iowa Soybean Association	• The Carpentries, Data and Software
• CyVerse	• John Deere	• The University of Tokyo
• Dryland Genetics	• Microsoft	• UNL Institute of Agriculture and Natural Resources, Center for Resilience in Agricultural Working Landscapes, National Research Traineeship
• EarthSense, Inc.	• Midwest Big Data Hub	• USDA-ARS
• EnGenious Ag	• Mineral - X, the moonshot factory	• Vermeer Corporation

More information	https://aiira.iastate.edu/

Note: For the FY columns, FY 2021 refers to actual budget, FY 2022 refers to planned budget, and FY 2023 refers to budget request.

5.2.6   Theme: AI for Accelerating Molecular Synthesis and Manufacturing

5.2.6.1   AI Institute for Molecular Discovery, Synthetic Strategy, and Manufacturing (also known as Molecule Maker Lab Institute). *NSF*

Year Launched	2020		
Focus	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	
• Pennsylvania State University	• Rochester Institute of Technology

Partners/Collaborators	
• Allchemy, Inc.	• Northwestern University

More information	https://moleculemaker.org/

5.2.7   Theme: AI for Discovery in Physics

5.2.7.1   AI Institute for Artificial Intelligence and Fundamental Interactions (IAIFI). *NSF*

Year Launched	2020		
Focus	Incorporate workforce development, digital learning, outreach, and knowledge transfer programs to develop AI methods that integrate the laws of physics as a guiding framework to advance physics knowledge—from the smallest building blocks of nature to the largest structures in the universe—and galvanize AI research innovation to broaden societal impacts.		
Funding	For information on funding, please see https://www.nsf.gov/awardsearch/showAward?AWD_ID=2019786.	**Primary Organization**	MIT

Other Principal Organizations		
• Harvard University	• Northeastern University	• Tufts University

Partners/Collaborators		
• Amazon	• Jefferson Laboratory	• Salesforce
• Argonne National Laboratory	• LIGO Scientific Collaboration	• Sony
• CERN	• Microsoft Research	• Mineral - X, the moonshot factory
• DeepMind	• MIT Bates Computing Center	• Xilinx
• Fermilab	• MIT-IBM Watson AI Lab	• Yandex
• IBM	• Nvidia Corporation	

More information	https://iaifi.org/

5.2.8   Theme: AI in Dynamic Systems

5.2.8.1   AI Institute in Dynamic Systems. *DHS, NSF*

Year Launched	2021		
Focus	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.		
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
Partners/Collaborators			
• Boeing Advanced Research Center		• Pacific Northwest National Laboratories	
More information	http://dynamicsai.org/		

5.2.9   Theme: Foundations of Machine Learning

5.2.9.1   AI Institute for Foundations of Machine Learning. *NSF*

Year Launched	2020		
Focus	Address major theoretical challenges in AI, including next-generation algorithms for deep learning, neural architecture optimization, and efficient robust statistics. Major online coursework and research initiatives will bring current AI tools to thousands of students and professionals across the country. The Dell Medical School at University of Texas at Austin will test algorithms developed in the Institute to expedite turnaround time for medical imaging diagnostics. Several major businesses have signed on to transfer Institute research into practice.		
Funding	For information on funding, please see https://www.nsf.gov/awardsearch/showAward?AWD_ID=2019844.	Primary Organization	University of Texas at Austin
Other Principal Organizations			
• Microsoft Research	• University of Washington	• Wichita State University	
Partners/Collaborators			
• City of Austin	• Internet Archive	• University of Texas at Austin Dell Medical School	
• Dell Technologies	• Netflix		
• Facebook	• Texas Advanced Computing Center	• YouTube	
More information	https://www.ifml.institute/		

5.2.10 Theme: Human-AI Interaction and Collaboration

5.2.10.1 AI Institute for Collaborative Assistance and Responsive Interaction for Networked Groups (AI-CARING). *NSF, Industry Partners*

Year Launched	2021		
Focus	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 to sustain independence, improve quality of life, and increase effectiveness of care coordination across the care network.		
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 State University
• Oregon Health & Science University	• University of Massachusetts Lowell

Partners/Collaborators

• AARP	• Jewish Healthcare Foundation	• People Power
• Achieva	• Morehouse School of Medicine	• Pittsburgh Healthcare System
• Apple	• NASA	• Sandia National Laboratories
• Briarcliff Oaks	• National Center for Women and IT	• St. Anne's Terrace, Inc.
• Cathedral Towers, Inc.	• National Church Residences, Trinity Towers	• Stanley Healthcare
• Chatham University	• NIST	• Toyota Research Institute
• Emory University	• Northern Essex Community College	• University of Pittsburgh
• Facebook	• Nvidia Corporation	• UPMC Enterprises
• Hello Robot	• Oak Ridge National Laboratory	• VA
• Jet Propulsion Laboratory		

More information	http://ai-caring.org/

5.2.11 Theme: Trustworthy AI

5.2.11.1 AI Institute for Research on Trustworthy AI in Weather, Climate, and Coastal Oceanography (also known as AI Institute for Artificial Intelligence for Environmental Sciences, or AI2ES). *NSF*

Year Launched	2020		
Focus	Assemble researchers in AI, atmospheric and ocean science, and risk communication to develop user-driven trustworthy AI that addresses pressing concerns in weather, climate, and coastal oceanography and coastal hazards prediction. With AI certificate programs aimed at workforce skills, the institute is providing the research and training necessary for the future workforce to deliver the advances needed to deal with forecasting and prediction challenges.		
Funding	For information on funding, please see https://www.nsf.gov/awardsearch/showAward?AWD_ID=2019758.	**Primary Organization**	University of Oklahoma

Other Principal Organizations		
• Colorado State University	• North Carolina State University	• University at Albany
• Del Mar College	• Texas A&M University Corpus Christi	• University of Washington
• UCAR National Center for Atmospheric Research		

Partners/Collaborators		
• City of Corpus Christi	• NOAA Cooperative Institute for Environmental Services Global Systems Lab	• NY Power Authority
• DHS	• NOAA Earth System Research Labs Global Systems Lab	• NY Thruway
• Disaster Technologies. Inc.	• NOAA National Geodetic Survey	• Oklahoma Climate Survey
• DOT Department of Environmental Conservation	• NOAA National Severe Storms Lab Storm Prediction Center	• Texas Coastal Offices of the National Weather Service
• Google	• NOAA Operational Oceanographic Products & Services	• Texas Commission on Environmental Quality
• Joint Typhoon Warning Center	• Nueces County Coastal Parks	• Texas DOT
• National Hurricane Center	• Nvidia Corporation	• Texas General Land Office
• National Park Service	• NY Independent System Operator, Inc.	• The Weather Company, IBM

More information	https://www.ai2es.org/

Appendix A. List of Abbreviations and Acronyms

Item	Spell-out
ACL	Administration for Community Living
ACNS	Advanced Communication Networks and Systems (PCA)
AFOSR	Air Force Office of Scientific Research
AFRI	Agriculture and Food Research Initiative
AFRL	Air Force Research Laboratory
AgAID	USDA-NIFA Institute for Agricultural AI for Transforming Workforce and Decision Support
AHRQ	Agency for Healthcare Research and Quality
AI	artificial intelligence
AI/ML	artificial intelligence and machine learning
AI-CARING	NSF AI Institute for Collaborative Assistance and Responsive Interaction for Networked Groups
AI-EDGE	NSF AI Institute for Future Edge Networks and Distributed Intelligence
AI2ES	NSF AI Institute for Artificial Intelligence for Environmental Sciences
AI4Opt	NSF AI Institute for Advances in Optimization
AIFARMS	USDA-NIFA AI Institute for Artificial Intelligence for Future Agricultural Resilience, Management, and Sustainability
AIFS	USDA-NIFA AI Institute for Next Generation Food Systems
AIIRA	USDA-NIFA AI Institute for Resilient Agriculture
AIM-AHEAD	Artificial Intelligence/Machine Learning Consortium to Advance Health Equity and Researcher Diversity
ALOE	NSF AI Institute for Adult Learning and Online Education
ANSI	American National Standards Institute
AR	augmented reality
ARL	Army Research Laboratory
ARO	Army Research Office
ASTM	ASTM International (formerly known as American Society for Testing and Materials)
AWN	Advanced Wireless Networks
AWRD	Advanced Wireless R&D (Sub-PCA)
AWS	Amazon Web Services
BARDA	Biomedical Advanced Research and Development Authority
BD	Big Data (IWG)
BLS	Bureau of Labor Statistics
BRD	Broadband Research and Development
C4I	Command, Control, Communications, Computers, and Intelligence
C5ISR	Command, Control, Computers, Communications, Cyber, Intelligence, Surveillance and Reconnaissance Center
CCDC	Combat Capabilities Development Command (Army)
CDC	Centers for Disease Control and Prevention
CDS	Clinical Decision Support
CDS&E	Computational and Data-Enabled Science and Engineering

Item	Spell-out
CG	U.S. Coast Guard
CHuman	Computing-Enabled Human Interaction, Communication, and Augmentation (PCA)
CIA	Central Intelligence Agency
CISA	Cybersecurity and Infrastructure Security Agency
CISE	Computer and Information Science and Engineering
CMS	Centers for Medicare & Medicaid Services
CNPS	Computing-Enabled Networked Physical Systems (IWG)
COVID-19	Coronavirus Disease 2019
CPS	Cyber-Physical Systems
CSIA	Cyber Security and Information Assurance
CSP	Cyber Security and Privacy
CSSI	Cyberinfrastructure for Sustained Scientific Innovation
DARPA	Defense Advanced Research Projects Agency
DEA	Drug Enforcement Administration
DEVCOM	U.S. Army Combat Capabilities Development Command
DevSecOps	Development Security Operations
DHA	Defense Health Agency
DHRD	Digital Health Research and Development (IWG)
DHS	Department of Homeland Security
DHS CWMD	Department of Homeland Security Countering Weapons of Mass Destruction Office
DIU	Defense Innovation Unit
DOC	Department of Commerce
DoD	Department of Defense
DoD CIO	Department of Defense Chief Information Officer
DoD DAF	Department of Defense Department of the Air Force
DOE	Department of Energy
DOE/AITO	Department of Energy Artificial Intelligence & Technology Office
DOE/ARPA-E	Department of Energy Advanced Research Projects Agency–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/OE	Department of Energy Office of Electricity
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

Item	Spell-out
DOT FRA	Department of Transportation Federal Railroad Administration
DREN	Defense Research and Engineering Network
DSRC	DoD Supercomputing Resource Centers
DTRA	Defense Threat Reduction Agency
eCare	Electronic Care
ECP	Exascale Computing Project
ED-IES	Department of Education Institute of Education Sciences
EdW	Education and Workforce (PCA)
EHCS	Enabling R&D for High-Capability Computing Systems (PCA)
ENIT	Electronics for Networking and Information Technology (PCA)
EPA	Environmental Protection Agency
ERI	Electronics Resurgence Initiative
FAA	Federal Aviation Administration
FACE	Future Advanced Computing Ecosystem
FAIR	findability, accessibility, interoperability, and reusability
FBI	Federal Bureau of Investigation
FCC	Federal Communications Commission
FDA	Food and Drug Administration
FHWA	Federal Highway Administration
FinCEN	Financial Crimes Enforcement Network
FMCSA	Federal Motor Carrier Safety Administration
FTA	Federal Transit Administration
FTAC	Fast Track Action Committee
FTC	Federal Trade Commission
GSA	General Services Administration
HCC	high capability computing
HCIA	High-Capability Computing Infrastructure and Applications (PCA)
HEAL	Helping to End Addiction Long-term®
HEC	high end computing
HHS	Department of Health and Human Services
HITRD	Health IT R&D IWG (replaced by DHRD)
HPC	high performance computing
HRI	human-robot interaction
HRSA	Health Resources and Services Administration
IAIFI	NSF AI Institute for Artificial Intelligence and Fundamental Interactions
IARPA	Intelligence Advanced Research Projects Activity
ICDI	Integrated Computational and Data Infrastructure
ICICLE	NSF AI Institute for Intelligent Cyberinfrastructure with Computational Learning in the Environment
IEEE	Institute of Electrical and Electronics Engineers

Item	Spell-out
IHS	Indian Health Service (within HHS)
IIRD	Information Integrity Research and Development (IWG)
IoT	Internet of Things
IRAS	Intelligent Robotics and Autonomous Systems (IWG)
iSAT	NSF AI Institute for Student-AI Teaming
ITA	International Trade Administration
ITS JPO	Intelligent Transportation Systems Joint Program Office
IWG	Interagency Working Group
JAIC	Joint Artificial Intelligence Center
JET	Joint Engineering Team
LEAP	Leading Edge Acceleration Projects
LSDMA	Large-Scale Data Management and Analysis (PCA)
LSN	Large Scale Networking (IWG)
MAGIC	Middleware and Grid Interagency Coordination (team)
MARAD	Maritime Administration
MDA	Missile Defense Agency
ML	machine learning
MLAI-SC	Machine Learning and Artificial Intelligence Subcommittee
MSI	Minority-Serving Institution
MURI	Multidisciplinary University Research Initiative
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
NCCoE	National Cybersecurity Center of Excellence
NCHS	National Center for Health Statistics
NCI	National Cancer Institute
NCO	National Coordination Office
NHTSA	National Highway Traffic Safety Administration
NICE	National Initiative for Cybersecurity Education
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
NITRD	Networking and Information Technology Research and Development
NLM	National Library of Medicine
NMIO	National Maritime Intelligence-Integration Office
NOAA	National Oceanic and Atmospheric Administration

Item	Spell-out
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
NSCR	National Strategic Computing Reserve
NSF	National Science Foundation
NSTC	National Science and Technology Council
NTIA	National Telecommunications and Information Administration
NTSB	National Transportation Safety Board
ODNI	Office of the Director of National Intelligence
OMB	Office of Management and Budget
ONC	Office of the National Coordinator for Health Information Technology (within HHS)
ONR	Office of Naval Research
OSD	Office of the Secretary of Defense
OSHA	Occupational Safety & Health Administration
OSTP	Office of Science and Technology Policy
OUSD(R&E)	Office of the Under Secretary of Defense for Research and Engineering
PCA	Program Component Area
PCOR	Patient-Centered Outcomes Research
PHMSA	Pipeline and Hazardous Materials Safety Administration
PPoSS	Principles and Practice of Scalable Systems
PRO	Patient-reported Outcomes
QIS	quantum information science
R&D	research and development
RADx	Rapid Acceleration of Diagnostics
RADx-rad	Rapid Acceleration of Diagnostics Radical
RADx-UP	Rapid Acceleration of Diagnostics Underserved Populations
RAPID	Rapid Response Research
RF	radio frequency
ROK	Republic of (South) Korea
S&E	science and engineering
S&T	science and technology (or Science & Technology Directorate)
S&TCD	(C5ISR) Space and Terrestrial Communications Directorate
SAMHSA	Substance Abuse and Mental Health Services Administration
SARS-CoV-2	Severe Acute Respiratory Syndrome Coronavirus 2 (the virus that causes COVID-19)
SBIR	Small Business Innovation Research
SciDAC	Scientific Discovery Through Advanced Computing

Item	Spell-out
SPSQ	Software Productivity, Sustainability, and Quality (IWG)
SSA	Social Security Administration
STEM	science, technology, engineering, and mathematics
STRIDES	Science and Technology Research Infrastructure for Discovery, Experimentation, and Sustainability
STTR	Small Business Technology Transfer
TCSC	Technology Cooperation Sub-Committee
TILOS	NSF AI Institute for Learning-Enabled Optimization at Scale
TRMC	Test Resource Management Center
USACE	U.S. Army Corps of Engineers
USAID	U.S. Agency for International Development
USAMRDC	U.S. Army Medical Research and Development Command
USDA	United States Department of Agriculture
USDA-ARS	United States Department of Agriculture Agricultural Research Service
USDA-NIFA	U.S. Department of Agriculture National Institute of Food and Agriculture
USGS	U.S. Geological Survey
USPTO	United States Patent and Trademark Office
USSF	U.S. Space Force
VA	Department of Veterans Affairs
VIA	Video and Image Analytics (team)
WSRD	Wireless Spectrum Research and Development (IWG)
XSEDE	Extreme Science and Engineering Discovery Environment

NATIONAL SCIENCE AND TECHNOLOGY COUNCIL

SUBCOMMITTEE ON NETWORKING AND INFORMATION TECHNOLOGY
RESEARCH AND DEVELOPMENT

SELECT COMMITTEE ON ARTIFICIAL INTELLIGENCE

MACHINE LEARNING AND ARTIFICIAL INTELLIGENCE SUBCOMMITTEE

NATIONAL ARTIFICIAL INTELLIGENCE INITIATIVE OFFICE

30 YEARS NITRD

Three Decades of Impact and Breakthroughs in Networking and Information Technology Research

https://www.nitrd.gov/   **https://www.ai.gov/**