Appendix C: FY2025 IWG Priorities and Associated Programs/Activities

THE NETWORKING & INFORMATION TECHNOLOGY R&D PROGRAM AND THE
NATIONAL ARTIFICIAL INTELLIGENCE INITIATIVE OFFICE

SUPPLEMENT TO THE PRESIDENT'S FY2025 BUDGET

A report by the

SUBCOMMITTEE ON NETWORKING & INFORMATION TECHNOLOGY RESEARCH & DEVELOPMENT

and the

SUBCOMMITTEE ON MACHINE LEARNING & ARTIFICIAL INTELLIGENCE

of the

NATIONAL SCIENCE & TECHNOLOGY COUNCIL

November 2024

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FY2025 IWG Priorities and Associated Programs and Activities

1.0 Advanced Communication Networks and Systems (ACNS) PCA

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

1.1 Large Scale Networking (LSN) IWG

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 robust transfer of data among ground, sea, air, and space systems.

Agencies: AFRL, Army/C5ISR, DAF, DHS, DOC (NIST, NOAA, NTIA), DOD (DARPA, HPCMP, NSA), DOE/SC, DOI, DOJ, DOT, FCC, GSA, HHS/NIH, NASA, Navy & NSF

1.1.1 Strategic Priorities & Associated Key Programs/Activities

1. Promote long-term research in concepts, techniques, architectures, and protocols for future networks.

- **Convergence Accelerator (Track G: Securely Operating Through 5G Infrastructure):** Funds solutions to enhance end devices and/or augmentations to 5G infrastructure to enable operators to operate through public 5G networks, while meeting security/resilience requirements. **NSF & DOD**
- **Agile Waveform Design for Communication Networks in Contested:** Ensures that future communication protocols used by the Air Force are suitable for data-heavy tasks. **AFRL**
- **Directional Mesh Networking:** Provides fault tolerant network topologies and range extension in contested environments. **AFRL**
- **Machine Learning Enabled Tactical Network Monitoring & Management:** Removes time as the limiting factor from current day Joint Interface Control Officer. **AFRL**
- **Multi-Mission Software Defined Radio (SDRF++):** Leverages technology advances in hardware and software to build next generation "SDRF" airborne capabilities for operationally agile systems. **AFRL**
- **Waveform design and Optimization for Mil-specific Operations:** Performs side-by-side evaluation of mil-specific waveform features. **AFRL**
- **Predictive Intelligent Networking:** Provides a self-aware and optimized Army network utilizing transport resources that proactively adjust under evolving threat conditions. **C5ISR**
- **Mission-Integrated Network Control:** Creates autonomous network discovery and mission-driven control enabling remote, intelligent control of heterogeneous networks. **DARPA**
- **Space-Based Adaptive Communications Node:** Connects heterogeneous constellations through reconfigurable multi-protocol intersatellite optical communications terminal. **DARPA**
- **Quantum Networking:** Supports R&D on quantum repeater devices, quantum error mitigation, quantum network architecture/protocols, & quantum-classical hybrid/integrated networks. **DOE/SC**
- **Defense Research and Engineering Network (DREN) 4:** Deploys Precision Time Protocol, enhances routing and switching capabilities, and deploys virtualization and orchestration capabilities within DREN 4 intelligent core and Network Operation Center on DREN 4. **HPCMP**
- **DREN 5:** Initiates conceptual architecture and protocol plans for DREN 5 (follow-on to DREN 4). **HPCMP**

- **Network Synchronization:** Continues development of network synchronization. **Navy**
- **Artificial Intelligence/Machine Learning (AI/ML):** Provides a tool for AI-based fall-risk assessment in post stroke survivors and ML approaches to radiological dating of infant clavicle fractures. **NIH**
- **Mobile Health (mHealth):** Supports development of a novel mHealth platform to track health behaviors of young children with Down Syndrome. **NIH**
- **TeleHealth:** Implements telemedicine and social network driven Human Immunodeficiency Virus (HIV) service uptake for comprehensive HIV service integration in rural syringe service programs. **NIH**
- **Quantum Information Networks:** Supports research and develops quantum devices and their use in quantum communications and networking applications. **NIST**
- **N-Wave/NOAA Cyber Security:** Uses Resource Public Key Infrastructure to ensure N-Wave netblocks have Route Origin Authorizations entered through American Registry for Internet Numbers. **NOAA**
- **Defensive Cyber Deception:** Uses a network decoy prototype to understand the effectiveness of defensive cyber deception. **NSA**
- **Trusted Computing:** Explores trusted computing security primitives that further the foundations and applications of trust and trustworthiness of devices and systems. **NSA**
- **Breaking the Low Latency Barrier for Verticals In Next-G Wireless Networks:** Seeks to identify/solve critical architectural and technological issues that must be resolved in current 5G and Next-G wireless networks. **NSF**
- **Campus Cyberinfrastructure:** Invests in campus-level data and networking infrastructure and integration activities tied to achieving higher levels of performance. **NSF**
- **Community Infrastructure for Research in Computer and Information Science and Engineering:** Enables new research in future networks. **NSF**
- **Core Networking Technology & Systems:** Supports foundational research on computer networking, including NextG and Quantum Networking. **NSF**
- **FABRIC:** Supports mid-scale research infrastructure program, now moved to the operational phase. **NSF**

2. Enable cloud infrastructure enhancements from enterprise to tactical edge including standards and guidance for the adoption of cloud computing.

- **Connecting the Combat Cloud:** Connects tactical information seamlessly across multiple domains on-demand and at scale. **AFRL**
- **Mission-Responsive Information Exchange:** Provides internet-like connectivity from enterprise to the tactical edge. **AFRL**
- **Space Combat Cloud:** Develops a space cloud leverage commercial Satellite Communications (SATCOM) providers with massively proliferated constellations to include high throughput satellites. **AFRL**
- **Cloud, HPC, Edge, Real-Time Analytics:** Research new data architectures, storage, and computational/analytic technologies incorporating security and privacy for multi-cloud and edge applications. **DHS**
- **DREN:** Enhances DREN Boundary Cloud Access Point, DREN Direct Connect Cloud Access, and Secret DREN connections to Secret commercial cloud providers. **HPCMP**
- **Telehealth Intervention to Increase Screening and Treatment for Alcohol Use Disorder:** Uses a large electronic health record system to identify patients at increased risk for occult alcohol use disorder. **NIH**

- **Virtual Screening Brief Intervention Referral to Treatment (SBIRT) for Pediatric Primary Care:** Works to improve early identification and treatment for Alcohol and other drug (AOD) and comorbid mental health problems among adolescents at high or severe risk of AOD use disorder. **NIH**
- **NIST Cloud Computing Program:** Participates in Project Agility, an international collaboration for Intercloud Interoperability and Federation in the development of a 5G Federated Testbed. **NIST**
- **Cyclone:** Supports research towards protecting sensitive data in use for large dynamic distributed systems (i.e. clouds). **NSA**
- **Chameleon & CloudLab:** Provides multi-site experimental computing & networking infrastructure to innovate for future cloud computing software and networks. **NSF**
- **DeltaAI:** Deploys DeltaAI, an advanced computing and data resource. **NSF**

3. Scale data-intensive workload and management capabilities to meet the requirements of applications such as data modeling and analytics.

- **Privacy-Preserving Data Sharing in Practice (PDaSP):** Enhances the ability to privately share and analyze data for a range of use cases and applications to solve real world problems. **DOT, FHWA, NIST & NSF**
- **Android Team Awareness Kit (ATAK) as a platform for ML:** Expands AFRL's Situational Awareness mobile platform capability to leverage the power of the ML community. **AFRL**
- **Enhanced network architecture for data analytics Foundation: ATAK:** Provides command and control & situational awareness capabilities across federal and civilian use cases. **AFRL**
- **Multi-level Security enabling Tactical Joint-Coalition Sharing:** Enables seamless transfer and access of information across security domains and joint-coalition partners while balancing risk. **AFRL**
- **Intelligence, Surveillance, and Reconnaissance Optimization for Multi-Domain Operations Support:** Enables the orchestration of multi-intelligence sensors and processing to give soldiers at all echelons access to sensors and the ability to conduct ad-hoc tipping and cueing missions. **C5ISR**
- **DREN:** Continues the Integrated Library for Advanced Network Data Science research collaboration efforts. **HPCMP**
- **DREN:** Enhances DREN Active Measurement Program. **HPCMP**
- **Penny Chatbot:** Adapts the Penny Chatbot for perinatal OUD patients. **NIH**
- **The Pediatric Food Intake Technology System:** Addresses the outstanding need for a technologically advanced dietary assessment tool specific to the U.S. pediatric population. **NIH**
- **Wireless withdrawal detection and monitoring system for neonatal abstinence syndrome:** Develop, assess, and commercialize interlinked, infant-targeted wearable biosensor-systems. **NIH**
- **Network Analysis:** Continue optimization Grafana dashboards for availability of critical enterprise services and custom dashboards for customer direct needs. **NOAA**
- **Technology Development and Innovation Program:** Integrates N-Wave network lab operations automation and processes with NOAA Cyber Security functions. **NOAA**
- **5G Open Source Network Orchestrator - Open Network Automation Platform:** Enables rapid automation of complete lifecycle management critical for 5G and next-generation networks. **NSA**
- **AI/ML-Scalable AI Approaches for Cyberthreat Remediation, Elimination, and Deterrence:** Addresses speed and scale-move to human-aided, adaptive and automated cyber defense capabilities. **NSA**
- **AI Institutes:** Promotes advances in AI and Computer and Network Systems. **NSF**
- **International Research Network Connections:** Supports multi-agency global scientific research collaborations. **NSF**

4. Achieve new levels of security and resilience for emerging wireless networks and multidomain internets and to protect core infrastructure.

- **Quantum Communications & Networking:** Drives innovation beyond in-house demonstration of 1st DOD trapped ion capability, scale from point-to-point to multi-node mesh network. **AFRL**
- **Resilient black core routing:** Provides encrypted mission data routing & throttling from various security enclaves via mission-oriented quality of service metrics. **AFRL**
- **Viability Assessment for Ultra-broadband Long-range THz Comm:** Supports world's first long range THz comms experiment - ground to ground. **AFRL**
- **Autonomous Cyber Research:** Develops cyber tools to secure automated network decisions and defend against adaptive, autonomous cyber-attacks at machine speed. **C5ISR**
- **Public Key Infrastructure Modernization & Dynamic Access Control for Tactical:** Improves network security posture by enforcing least privilege & just-in-time network access. **C5ISR**
- **Tactical Zero Trust:** Adapts enterprise zero trust principles and tools to Denied, Disrupted, Intermittent, and Limited tactical environments. **C5ISR**
- **DREN:** Enhances DREN Security Gateway for Internet boundary protection, enhances Internet Routing Security, and enhances DREN Cyber Security Sensor. **HPCMP**
- **Cyber Kevlar:** Matures Total Platform Cyber Protection tools and integrates them into existing Navy development, security and operations processes. **Navy**
- **Total Platform Cyber Protection:** Develops automated tools and methods for late-stage transformation of software used by DOD to reduce the attack surface. **Navy**
- **mHealth platform:** Engineers a mobile health platform for the pediatric care setting to promote longer sleep duration for childhood obesity prevention. **NIH**
- **Opioid induced respiratory depression:** Develops wearable sensors to track the variation of physiological parameters for the real-time detection of an opioid overdose. **NIH**
- **Wearable sensor for opioids detection:** Develops a new electrochemical sensor array for a wearable sensor for opioids detection. **NIH**
- **Advanced Security Architectures for Next Generation Wireless:** Creates practical solutions to strengthen security and enable the security features provided by the current 5G standards. **NIST**
- **Foundational Internet Protocols:** Works with the Internet Engineering Task Force and operator community to design, standardize and foster adoption of new technologies to address security and resilience issues in the Internet's core infrastructure. **NIST**
- **Industrial/Operational Technology Networks:** Develops security guidance for a broad range of industrial control systems, electrical power grid, smart manufacturing and specific use cases. **NIST**
- **Internet of Things (IoT) Network Security:** Develops technology standards, deployment guidance, and security profiles for consumer/enterprise IoT use cases. **NIST**
- **Internet Protocol version 6 (IPv6)-Only Networks:** Develops security and deployment guidance, standards profiles and test programs to support the transition to IPv6-only networks. **NIST**
- **Trustworthy Networks Program:** Advances the research, standardization and adoption of technologies to increase the security, privacy, and performance of networked systems. **NIST**
- **Zero Trust Networks:** Develops architectural and deployment guidance to support USG-wide initiatives in Zero Trust security. **NIST**
- **N-Wave:** Evaluates the wireless infrastructure to support full wireless office, integrates location services support reintegration, and enhances contact tracing and emergency management. **NOAA**
- **5G Standards:** Contributes to the main 5G Standards Body (3rd Generation Partnership Project - 3GPP). **NSA**

- **Cybersecurity Innovation for Cyberinfrastructure Program:** Develops, deploys, and integrates security solutions that ensure the integrity, resilience, and reliability of scientific workflows. **NSF**
- **Mid-scale research infrastructure Program:** Supports infrastructure that is diverse in space, cost, and implementation time. **NSF**
- **National Radio Dynamic Zone:** Seeks to foster collaboration among spectrum sharing researchers and advance the use of dynamic spectrum sharing. **NSF**
- **Secure and Trustworthy Cyberspace program:** Supports research addressing cybersecurity and privacy. **NSF**
- **Office of Advanced Cyberinfrastructure - Research Core Program**: Supports translational research and education activities that lead to deployable, scalable, and sustainable systems. **NSF**

5. Advance wireless networks through innovations such as the use of nontraditional waveforms and the deployment of nationwide testbeds.

- **Open / Virtualized Radio Access Networks:** Develops standards for Open Radio Access Networks with a focus on security, resilience, testing, and mission critical applications. **DOD, DHS, FCC, NIST & NTIA**
- **Device to Device Communication:** Conducts research on multi-hop user equipment relays to increase resiliency in tactical and public safety environments. **DOD, DOT & NIST**
- **All Weather, All year, Large Scale Curated Measurement Capability:** Performs automated measurements over 30km for high multi-path scattering. **AFRL**
- **Extendable Mobile Ad-hoc Network Emulator Testbed for tactical waveform assessment:** Provides performance assessment in contested environments. **AFRL**
- **Relay for Air Non-Line-of-Sight Ground Environments:** Provides improved communications range and better coverage in non-line-of-sight environments for communications links. **C5ISR**
- **Resilient Wideband SATCOM:** Increases the resiliency of wideband SATCOM to support Multi-Domain Operations in a congested and contested environment. **C5ISR**
- **DREN:** Enhances DREN 4 Service Delivery Point-Lite capability over wireless networks. **HPCMP**
- **East Africa International Epidemiology Database to evaluate Acquired immunodeficiency syndrome Regional Consortium:** Provides a rich resource for globally diverse HIV data. **NIH**
- **Harmonist**: Develops data standards, software, and methods to help HIV observational research consortia coordinate multiregional research projects. **NIH**
- **Reaching Rural Veterans:** Addresses the significant challenges of providing evidence-based non-pharmacologic pain management to rural-dwelling veterans. **NIH**
- **Office of the Chief Information Officer/N-Wave:** Facilitates the integration of AI, analyze telemetry and other Key Performance Indicators. **NOAA**
- **IoT Monitoring and Anomaly Detection System:** Monitors IoT wireless protocols and use AI/ML to alert on anomalies in real-time. **NSA**
- **Platforms for Advanced Wireless Research:** Investigates advanced wireless systems and technologies. **NSF**

1.2 Advanced Wireless R&D (AWRD) Sub-PCA and Wireless Spectrum R&D (WSRD) IWG

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

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

Agencies: Army (DEVCOM, C5ISR), DAF/AFRL, DOD (DARPA, OUSD(R&E)), DOC (NIST, NOAA), DOE, DOI, DOT, FDA, NASA, Navy, NSF & NTIA

1.2.1 Strategic Priorities & Associated Key Programs/Activities

1. Improve capability of spectrum-dependent federal and private sector systems to operate in shared, congested, and new/higher frequency spectrum bands.

- **National Advanced Spectrum and Communications Test Network (NASCTN) - Citizens Broadband Radio Service (CBRS), Sharing Ecosystem Assessment**: Collects data to ascertain the effectiveness of the sharing ecosystem between CBRS and DOD systems. **DOD, NASA, NIST & NTIA**
- **Relay for Air Non-Line-of-Sight Ground Environments:** Provides improved communications range and better coverage in non-line-of-sight environments. **DEVCOM & C5ISR**
- **Resilient Wideband SATCOM:** Increases the resiliency of wideband SATCOM to support Multi-Domain Operations in a congested and contested environment. **DEVCOM & C5ISR**
- **Short Course:** Develops an Interference Protection Criteria/Interference Analysis short course with an emphasis on FY2024 Military Communications. **NTIA & NSF**
- **Extendable Mobile Ad-hoc Network Emulator Testbed for tactical waveform assessment:** Assesses performance in contested environments in initial prototype waveform environment. **AFRL**
- **Tactical Software Defined Networking:** Provides mobility assessment for event-based synchronization of Software Defined Networks controllers. **AFRL**
- **Argonne National Labs Electromagnetic Emission from 5G and the Environment:** Studies the frequency signal to be used as a carrier for instrumentation and sensing. **DOE**
- **Idaho National Labs (INL) 5G Dynamic Spectrum Analysis:** Provides data and analysis supporting policy recommendations for informed decisions on spectrum efficiency and sharing. **DOE**
- **Pacific Northwest National Labs Grid Security:** Uses Software Defined Radios to better secure operational networks in the energy sector. **DOE**
- **Space-based optical communications:** Advances and demonstrates space-based optical communications technologies. **NASA**
- **Space-based radiofrequency (RF) communications:** Expands use of the growing commercial market and to develop RF capabilities in higher frequency bands. **NASA**
- **Tactical 5G Implementation:** Develops technologies for end user equipment to authenticate base station and improve transmission security [e.g., power control, feature removal, etc.]. **Navy**
- **Adaptive dynamic communication systems:** Tests novel closed box methods for assessing interference. **NIST**
- **Dynamic spectrum sharing:** Uses new metrology to assess fair co-existence and optimization through ML and AI-based techniques using new metrology. **NIST**
- **Next Generation Wireless:** Validates millimeter-wave and sub-THz bands; develops novel propagation models; and disseminates measurement data and models. **NIST**
- **Noise:** Advances fundamental noise metrology that determines the sensitivity limits of spectrum sensing equipment. **NIST**

- **Convergence Accelerator (Track G: Securely Operating Through 5G Infrastructure):** Funds solutions to enhance end devices and/or augmentations to 5G infrastructure to enable operators the capability to operate through public 5G networks, while meeting security/resilience requirements. **NSF**
- **Electrical, Communications and Cyber Systems Core Research Programs:** Supports innovative research for communications and sensing. **NSF**
- **Multi-Input/Multi-Output and RAN Spectrum Sharing:** Designs, integrates, and evaluates a 5G enhancement for the 3.1 - 3.45 GHz shared 5G and military radar bands. **OUSD(R&E)**
- **Next Era of Wireless and Spectrum:** Supports fundamental research to develop the intellectual capital enabling the U.S. to smoothly and quickly transition to effective new ways of using and managing the radio and optical spectrum after the end of the current spectrum era of long-term exclusive-use license auctions. **NSF**
- **Risk Informed Spectrum Access:** Funds electromagnetic spectrum research. **OUSD(R&E)**

2. Improve capability of future generation federal and private sector wireless systems to simultaneously meet competing requirements (e.g., security, privacy, capacity, latency, energy consumption, spectrum coexistence, and efficiency).

- **Resilient and Intelligent Next-Generation Systems (RINGS):** Accelerates research impact on emerging communication, networking, sensing, and computing systems, along with global-scale services. **DOD, NIST, NSF & OUSD(R&E)**
- **Open Programmable Systems 5G:** Creates open source software and systems that enable secure 5G and subsequent mobile networks. **DARPA & OUSD(R&E)**
- **Public Safety Communications:** Develops communications and networking technologies and standards to increase efficiency, interoperability, and compatibility while addressing spectrum, utilization, network resiliency, cyber, and physical attack challenges. **DHS**
- **Spectrum Security and Engineering Center:** Assesses the impact of spectrum reallocation, performs modeling, and simulation of reallocation recommendations. **DOE**
- **Next Generation Wireless:** Develops and evaluates integrated communications and sensing systems; enables next generation communications systems. **NIST**
- **Over-the-Air Testing:** Develops measurement science to characterize the performance of wireless systems through measurements made in non-conductive environments. **NIST**
- **Quantum optical network technology:** Develops new measurement techniques, procedures, standards, and best practices to gain confidence in quantum optical network technology. **NIST**
- **Computer and Network Systems Core Research Programs:** Designs and analyses high-performance wireless networks, robust and manageable wired and wireless networks, security-by-design, mmWave, and THz networks. **NSF**
- **5G Open RAN:** Develops and supports 5G Open RAN and provides vendor neutral interoperability and testing platform for inter-agency projects. **NTIA**
- **Audio & Video Quality of Experience/Quality of Service:** Uses ML to build speech and video quality assessment tools for prediction of Quality of Experience. **NTIA**

3. Promote unprecedented spectrum access through better spectrum management processes, systems, tools, and data. Contribute to the National Spectrum R&D Roadmap.

- **NASCTN:** Provides robust test processes and validated measurement data necessary to develop, evaluate and deploy spectrum sharing technologies. **DOD, NASA, NIST, NOAA, NSF & NTIA**
- **IT Modernization Initiative:** Provides improved engineering capabilities and enhanced data models to improve interference prediction and frequency nomination. **NASA & NTIA**

- **Next Gen Wireless Test Bed:** Creates full-scale, operationally realistic test and training events. **DOE**
- **Spectrum Innovation:** Conducts R&D on dynamic spectrum access to solve spectrum sharing gaps. **DOE**
- **NASA Electronic Radio Database System:** Maintains an extensive spectrum authorization data set enabling efficient and effective reporting and support to spectrum management processes. **NASA**
- **Spectrum Analysis Center:** Develops and maintains the necessary software to conduct analysis of spectrum access. **NASA**
- **NextG Channel Model Alliance Data Repository:** Maintains a shared database to improve the quality of research techniques used by leading wireless communications laboratories. **NIST**
- **Breaking the Low Latency Barrier for Verticals In Next-G Wireless Networks:** Seeks to identify/solve critical architectural and technological issues that must be resolved in current 5G and Next-G wireless networks. **NSF**
- **National Radio Dynamic Zones:** Accelerates the use of dynamic spectrum sharing through integrating end-to-end spectrum sharing solutions and deploying them in extended field trials that enhance spectrum access for operational facilities. **NSF**
- **Data Technology & Software Engineering:** Demonstrates key data formats, like Signal Metadata Format, through quality data releases of non-sensitive spectrum data. **NTIA**
- **Data Technology & Software Engineering:** Develops new data indexing and management solutions enabling efficient, transparent creation and use of spectrum data. **NTIA**
- **Office of Spectrum Management R&D:** Manages the Federal Government's use of the radio frequency spectrum, ensuring that domestic and international spectrum needs are satisfied. **NTIA**

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

- **Wireless Experimentation and Innovation:** Utilizes trusted standards in the design, planning, and testing of wireless experimentation and innovation. **DOE**
- **Remote Sensing:** Applies and develops signal processing techniques for both passive and active science sensors to detect and to remove or mitigate effects from RFI. **NASA**
- **Next Generation Wireless/ Spectrum Sharing and Sensing:** Uses Generative Adversarial Networks to characterize emissions from modern agile and dynamic communication systems. **NIST**
- **National Artificial Intelligence Research Institutes:** Supports the development of new AI Institutes. **NSF**
- **Propagation Library:** Provides open-source propagation models and tooling with cross-language support. **NTIA**

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

- **Cellular roaming interconnect security:** DOE/INL-DOD-NATO and Industry research collaboration. **DOE & DOD**
- **DOE/INL Wireless Security Institute conference series:** Holds bi-yearly conferences on spectrum research and new spectrum technologies. **DOE**
- **Regulatory Science Tools (RSTs):** Develops evaluation methods as RSTs for 5G-enabled medical extended reality based on 5G system failure mode analysis. **FDA**
- **Regulatory Science Tools:** Measures medical device requirements for connectivity quality of service and ongoing assessment of network Quality Overall Summary. **FDA**
- **5G Coexistence Testbed:** Enables side-by-side testing that emulates realistic configurations and scenarios that allows for close examination of critical communications systems. **NIST**

- **Antenna Communication and Metrology Laboratory:** Enables metrology research on advanced antenna systems operating in complex electromagnetic environments. **NIST**
- **Industrial Wireless Systems Testbed:** Integrates existing and emerging wireless technologies with live physical systems found in factories of all types. **NIST**
- **National Broadband Interoperability Testbed:** Provides a controlled environment with large anechoic and reverberation chambers for coexistence studies of radar, LTE, and Wi-Fi. **NIST**
- **NextG Channel Model Alliance:** Advances breakthrough measurement, calibration, and channel modeling approaches to support commercialization of next-generation wireless networks. **NIST**
- **Open RAN:** Investigates interoperability, security, resilience, and measurements to support intelligent control and open architectures. **NIST**
- **Simulation Tools for Wireless Communications:** Provides publicly available models and simulation tools for performance evaluation of wireless systems and protocols. **NIST**
- **Community Infrastructure for Research in CISE:** Supports advanced wireless testbeds. **NSF**
- **Industrial Innovation and Partnerships core programs:** Commercializes Intellectual Property (IP) derived from NSF-funded research. **NSF**
- **Platforms for Advanced Wireless Research:** Augmenting the PAWR testbeds' capacities for testing and validation of Open Radio Access Network (O-RAN) systems and subsystems. **NSF**
- **Federal Advanced Communications Test Site:** Makes accurate over-the-air measurements using precision test equipment. **NTIA**

6. Grow the spectrum workforce, increase policymaker and public understanding of spectrum considerations, and raise awareness of spectrum's importance to the country through enhancing education, workforce development, and public outreach on spectrum-related topics. Contribute to the National Spectrum Workforce Plan.

- **National Spectrum Workforce Plan:** Supports an academic team to convene the broad spectrum community in workshops/working groups & lead the development of the National Plan. **NSF & NTIA**
- **Scholar-In-Residence at FDA:** Supports academic researchers and students in conducting research on topics related to public health and emerging medical device technologies. **FDA & NSF**
- **Aviation Cyber Initiative Workforce Wireless Spectrum Security Training:** Provides training to airport security. **DOE**
- **Summer Office of Science and Engineering Labs Regulatory Research Experience:** Allows students to explore future career opportunities in a regulatory science environment. **FDA**
- **NIST Internship Programs:** Provides students enrolled in a wide variety of education institutions, with opportunities to work in agencies to explore federal careers while still in school. **NIST**
- **Experiential Learning for Emerging and Novel Technologies (ExLENT):** Aims to provide professionals in any field with an experiential learning opportunity that builds the skills and competencies they need to pivot into careers in key technologies. **NSF**
- **Workforce Development in Spectrum STEM:** Supports research experience opportunities and workshop for students on spectrum topics. **NSF**

2.0 Artificial Intelligence (AI) PCA

AI R&D advances responsible research in AI and associated AI topics; this includes research directly related to AI into: fundamental AI approaches; developing more effective human-AI collaboration; addressing ethical, legal, and societal implications; ensuring safety and security; developing training datasets and testing environments; and evaluating AI systems and creating standards and benchmarks.

2.1 Artificial Intelligence R&D IWG

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

Agencies: Army, DAF (ACC, AFIT, AFOTEC, AFRL, AFTC, SAF/AQ, Space Force), DHS, DOC (NIST, NOAA, NTIA, USPTO), DOD (CDAO, DARPA, DTRA, OUSD(R&E), TRMC), DOE/NNSA, DOE/SC, DOI (USGS), DOJ (FBI, NIJ), DOT (FAA, FHWA, NTSB), ED, HHS (ONC), IARPA, Marines, NAIIO, NASA, Navy, NIH (NCI, NIBIB, OBSSR), NSF, OPM, State, USAID & USDA-NIFA

2.1.1 Strategic Priorities & Associated Key Programs/Activities

1. Make long-term investments in fundamental and responsible AI research.

- **National Artificial Intelligence Research Institutes:** Advances research to build AI talent pool, and create nexus points for academia, government, and industry. **DHS, DOT, DOD, NIST, NSF & USDA-NIFA**
- **Viper Experimentation and Next-gen Operations Model:** Develops flying test beds to evaluate autonomous capabilities and responsible use of AI for aircraft control and mission execution. **ACC, AFRL, AFTC & SAF/AQ**
- **Artificial Intelligence Observatory:** Creates AI observatory as a generative AI tool developed to support test and acquisition professionals in administrative functions. **AFOTEC, AFTC & CDAO**
- **Foundational Research in Robotics:** Promotes research on robotic systems that exhibit significant levels of both computational capability and physical complexity. **NSF & USDA-NIFA**
- **Smart Health and Biomedical Research in the Era of Artificial Intelligence and Advanced Data Science:** Accelerates the development and integration of AI to support the transformation of health and medicine. **NIH & NSF**
- **Advanced Framework for Simulation, Integration, and Modeling:** Explores Machine Learning Battle Managers in constructive military utility analysis of advanced Direct Energy concepts. **AFRL**
- **Machine Intelligence for Nuclear Explosion Monitoring:** Develops analytical tools and data exploitation algorithms to detect, locate, and characterize seismic events and aid in distinguishing between natural and man-made events. **AFRL**
- **Resilient Autonomy and AI Technology AI Toolbox:** Enables the composition and delivery of mission-tailored AI and federating AI capabilities across Australia, United Kingdom, and U.S. (AUKUS). **AFRL**
- **Safe Trusted Autonomy for Responsible Spacecraft:** Develops agents that quickly reacts, plans, and decides on appropriate courses of action for inspection tasking in proximity. **AFRL**
- **AI Innovations Institute Collaborative Research Alliances:** Increases skills, knowledge, and associations for AI researchers, research interests in AI programs, and expand as a formidable AI research center. **Army**
- **Environment-driven Conceptual Learning:** Develops AI agents that learn from language and vision for collaborative analysis of image, video, and multimedia in time-sensitive tasks. **DARPA**
- **AI for Nuclear Deterrence:** Develops AI for reducing cost and schedule in the development lifecycle of a nuclear warhead system. **DOE/NNSA**
- **AI and Scientific Machine Learning:** Conducts AI research focused on the development of AI as an enabling technology for scientific insights and discovery. **DOE/SC**
- **AI for Science and Energy:** Conducts AI research focused on the use of AI for science & energy applications. **DOE/SC**

- **AI, ML and Data for Scientific User Facilities:** Develops AI research portfolios for autonomous experimentation and control, data analysis, and offline design and optimization of scientific user facilities. **DOE/SC**
- **Exploratory Advanced Research (EAR) Program:** Conducts risk research to plan, build, renew, and operate safe, congestion free, and environmentally sound transportation systems. **DOT**
- **Advanced Air Mobility:** Advances ML for commercial aviation, learning from increasingly heterogeneous data over wide range of time scales, Learning from All Operations. **NASA**
- **Advanced Information Systems Technology (AIST):** Supports research in digital twins for nowcasting, forecasting, and what-if exploration. **NASA**
- **Space Exploration:** Applies AI and communication architectures for multiple mission types in Long Range Robotic Space Exploration. **NASA**
- **Space Science:** Applies deep learning for predicting damage from asteroid impact. **NASA**
- **Surrogate Modeling:** Applies AI to identify key features from images such as air pollution to develop insights. **NASA**
- **Wildfire Fighting:** Utilizes space-based technologies, autonomy, and ML techniques to prevent and respond to wildfire. **NASA/California Department of Forestry and Fire Protection**
- **Theoretical Foundations of Deep Learning:** Develops a principled theory of deep learning, based on rigorous mathematical principles, that address foundational issues in the design/build/test pipeline. **Navy**
- **Brain Research through Advancing Innovative Neurotechnologies (BRAIN) Initiative Targeted BRAIN Circuits Projects - TargetedBCP:** Employs innovative, methodologically-integrated approaches to support brain related projects with transformative outcome within 5 years. **NIH**
- **Cognitive Systems Analysis of Alzheimer's Disease Genetic and Phenotypic Data:** Applies AI to identify gene mutations that cause or contribute to risk of/protection against the development of Alzheimer's disease and dementias. **NIH**
- **AI Research in Fundamental and Applied Science:** Develop approaches for new fundamental and applied AI research and insights across NIST research areas. **NIST**
- **Fundamental AI Research:** Develops brain-inspired (neuromorphic) AI hardware, algorithms, and training methods for information processing speed, energy efficiency, and connectivity. **NIST**
- **Responsible AI Research:** Conducts measurement research in Trustworthy and Responsible AI including expansion of the AI Risk Management Framework (RMF) and development of tools and best practices. **NIST**
- **Responsible AI Research:** Develops a companion resource to the AI RMF focused on generative AI, as directed by the AI EO 14110. **NIST**
- **Convergence Accelerator (Track B: AI & the Future of Work):** Funding solutions to train, reskill, and upskill the current and future workforce with industry needs and jobs of the future, as well as build a talent pipeline to stimulate the U.S. workforce. **NSF**
- **Convergence Accelerator (Track D: AI Driven Innovation via Data and Model Sharing):** Funding solutions to address data and model sharing challenges through tool and platform development to enable easy and efficient data matching and sharing. **NSF**
- **Computing & Communication Foundations Core Program:** Advances computing and communication theory, algorithms, architecture and the design of computers and software. **NSF**
- **Information & Intelligent Systems Core Program:** Performs research in the interrelated roles of people, computers, and information to increase the ability to understand data. **NSF**

- **NSF Regional Innovation Engines:** Fosters innovation ecosystems to impact the economy within a geographic region, address societal challenges, & advance national competitiveness, supporting the application of AI to a wide range of societal & economic challenges. **NSF**
- **Responsible Design, Development, and Deployment of Technologies (ReDDDoT)**: Invites proposals from teams that examine & demonstrate the principles, methodologies, and impacts associated with design/development/deployment of technologies in practice. **NSF**
- **Data Science for Food and Agricultural Systems:** Enables systems and communities to effectively integrate AI approaches to further U.S. food and agriculture enterprises. **USDA-NIFA**
- **Plant Breeding for Agricultural Production:** Improves crop productivity, efficiency, quality, and performance, encouraging explainable AI research related to theory, genetics, and crop models. **USDA-NIFA**
- **Rapid Response to Extreme Weather Events Across Food and Agricultural Systems:** Develops and deploys strategies to protect food and agricultural supply chains during and after weather-related disasters. **USDA-NIFA**
- **Specialty Crop Research Initiative:** Promotes collaboration, open communication, exchange of information, and development of resources to solve needs of various specialty crop industries. **USDA-NIFA**
- **Sustainable Agricultural Systems:** Uses integrated research outreach activities to solve present and future food and agricultural production system challenges. **USDA-NIFA**
- **AI use for Cooperative Patent Classification:** Classifies patent applications based on the cooperative patent classification scheme for operational assignment of work and symbol recommendation. **USPTO**

2. Develop effective methods for human-AI collaboration.

- **Autonomous Air Combat Operations (AACO) and Air Combat Evolution (ACE):** Advances data visualization for human machine teaming to reflect real-world dynamics. **AFRL, AFTC, DARPA, Navy & Marines**
- **Towards Autonomous Discovery in Science and Engineering:** Develops methods, algorithms, and software for enabling autonomous scientific discovery. **DOE/SC & international partners.**
- **Alert Management System:** Applies neural-network enabled satellite pattern of life monitoring and alerting. **AFRL**
- **AACO:** Advances AI research, development, and application for National AI Initiative and the DOD's AI and Autonomy modernization areas. **AFRL**
- **Generative C4I Program:** Enables the use of Large Language Models and Multi-modal Generative AI in IL 6 and above environments. **AFRL**
- **The AI Task Force program:** Develops and implements a lifecycle management framework for deployed AI capabilities. **AFRL**
- **Strengthening Teamwork for Robust Operations in Novel Groups Collaborative Research Alliances:** Develops foundation for enhanced teamwork within heterogeneous human-intelligent agent teams. **Army**
- **ACE:** Develops AI algorithms and novel human-machine interfaces to enable greatly enhanced human-AI collaboration and development of protocols to train human trust of AI. **DARPA**
- **Artificial Intelligence Cyber Challenge:** Creates AI systems capable of addressing cybersecurity issues such as the security of critical infrastructure and software supply chains. **DARPA**

- **Artificial Intelligence Reinforcements:** Creates an AI air combat capability compatible with existing sensors, electronic warfare, and weapons within dynamic and operational environments. **DARPA**
- **Automating Scientific Knowledge Extraction and Modeling:** Develops AI-based tools to create, sustain, and enhance complex models and simulators. **DARPA**
- **Computational Cultural Understanding:** Builds NLP technologies help to operate within the emotional, social, and cultural norms that differ across societies, languages, and group affinities. **DARPA**
- **Influence Campaign Awareness and Sensemaking:** Develops techniques and tools that enable analysts to detect, characterize, and track geopolitical influence campaigns. **DARPA**
- **Knowledge Management at Scale and Speed:** Develops knowledge management tools that can efficiently capture and disseminate knowledge by analyzing and reasoning with expertise, experience, and data. **DARPA**
- **Perceptually-Enabled Task Guidance:** Develops methods, techniques, and technology for AI assistants that provides just-in-time visual and audio feedback. **DARPA**
- **AI-assisted Operation and Discovery for Science:** Develops methods, algorithms, and software for enabling AI-assisted code generation, scientific discovery and facility operations. **DOE/NNSA**
- **Adaptive Human Computer Interfaces:** Advances Human-Computer and ML to understand normal usage patterns and identify anomalies due to crew member difficulties, such as health impairment. **NASA**
- **Aeronautics "Human Contributions to Safety" Task:** Develops understanding of humans' safety-producing behaviors to ensure Human-AI collaborative systems retain a robust capability for resilient performance. **NASA**
- **Developing and Evaluating a Machine-Learning Opioid Prediction & Risk-Stratification E-Platform:** Refines and validates algorithms to identify patients at risk for opioid overdose. **NIH**
- **AI Usability Applied Research:** Develops software and standards to lower barriers for AI-researcher interactions while enhancing AI-interpretability and trustworthiness. **NIST**
- **AI Usability Fundamental Research:** Examines and establishes measures of user trust in AI, and measures that quantify how humans and AI technologies affect interaction outcomes. **NIST**
- **Human-Centered Computing:** Supports interdisciplinary research in human-computer interaction. **NSF**
- **Human Language Technologies:** Supports research advancing AI and linguistics. **NSF**
- **Capacity Building Grants for Non-Land-Grant Colleges of Agriculture Program:** Develops and applies AI and computer vision for applications that monitor and measure enteric methane emissions. **USDA-NIFA**
- **Inventor Search Assistant:** Develops and applies AI to assist inventors to identify relevant documents, figures, and classification codes used to conduct a novelty search. **USPTO**
- **Patent Search AI:** Augments next generation patent search tool to assist examiners identify relevant documents and additional areas to search earlier within the search process. **USPTO**
- **Relevant Prior Art:** Develops automatic import of references from related applications into the file wrapper of an application being examined for consideration by the examiner. **USPTO**
- **USPTO Virtual Assistant:** Develops AI assisted virtual assistant for helping customers find answers to common questions on USPTO.gov. **USPTO**

3. Understand and address the ethical, legal, and societal implications of AI.

- **Federated and Privacy-Preserving AI Research:** Advances AI research and Privacy-Enhancing Technologies (PETs) from collectively shared datasets. **DOE/SC & NIH**
- **National AI Research Institutes for Trustworthy AI in Law & Society (TRAILS):** Integrates AI participation, technology and governance of AI systems. **NIST & NSF**
- **Autonomy Capability Team:** Designs AI systems that incorporate elements of trust, safety, and ethics. **AFRL**
- **Trustworthy and Scientifically Robust Artificial Intelligence:** Develops the mathematical foundation for verification and validation to develop and assess methods. **DOE/NNSA**
- **EAR Program:** Preserves privacy of human subjects in experiments while providing behavioral information and providing privacy for bystanders in image. **DOT**
- **DTRA Responsible AI Process (RAI):** Identifies and mitigates RAI risks in their development, acquisition, and use of AI/ML. **DTRA**
- **Established Program to Stimulate Competitive Research Rapid Response Research solicitation on ethical use of AI**: Develops technical reports on ethical AI framework. **NASA**
- **Established AI Tiger Team:** Develops AI governance and coordination plan/structure for NASA. **NASA**
- **Public trust of AI in precision Clinical Decision Support health ecosystem:** Measures public trust in AI-CDS for precision health by assessing expectation and how they are impacted by policies. **NIH**
- **Continued public attention on the use of AI in the criminal justice system:** Advances facial recognition, surveillance technologies, risk assessment, predictive policing, and forensic analysis technologies. **NIJ**
- **Law Enforcement Use of Person-based Predictive Policing Approaches:** Studies predictive forensic DNA and predictive policing. **NIJ**
- **Strengthening data-driven pretrial release in New Jersey**: Examines the Public Safety Assessment tool designed to yield objective pretrial release recommendations. **NIJ**
- **AI RMF:** Supports use case extensions, implementation tools, adoption, and development of profile for generative AI. **NIST**
- **Explainable and Interpretable AI, AI Transparency, and Privacy-preserving Machine Learning and Data Management**: Expands research programs that advance AI in these areas. **NIST**
- **Guidelines and Tools:** Creates guidelines for evaluating and implementing differential-privacy-guarantee protections, and develops practices to support minimum risk-management. **NIST**
- **TRAILS National AI Research Institute and AI Safety Institute (AISI) and Consortium:** Supports and collaborates in the research being performed. **NIST**
- **Trustworthy AI:** Conducts cognitive science research in understanding characteristics of trustworthy AI that will support future best practices. **NIST**
- **Designing Accountable Software Systems:** Advances deeper understanding and formalization of the relationship between software systems and the complex social and legal contexts within which they operate. **NSF**
- **Ethical and Responsible Research program:** Supports investigating the ethical consequences of research in emerging scientific and technological areas, including artificial intelligence, so that the research is responsive to societal needs. **NSF**
- **ReDDDoT:** Invites proposals from multidisciplinary/multi-sector teams that examine and demonstrate the principles/methodologies/implementations and impacts associated with design/development, and deployment of technologies in practice. **NSF**

- **Social Implications of Food and Agricultural Technologies:** Examines the social implications of technology as a form of technology assessment. **USDA-NIFA**
- **AI Patent Policy:** Publishes guidance on issues at the intersection of AI and patent policy, including inventorship for AI-assisted inventions and Updated Patent Subject Matter Eligibility Guidance. **USPTO**
- **AI's Role in the Inventive Process:** Engages stakeholders on AI-driven innovation via various public engagements to solicit comments and feedback. **USPTO**
- **Use of AI-Based Tools:** Informs practitioners and the public of the issues that patent & trademark professionals/innovators & entrepreneurs must navigate while using AI before the USPTO. **USPTO**

4. Ensure the safety and security of AI systems.

- **PDaSP:** Enhances the ability to privately share and analyze data for a range of use cases and applications to solve real world problems. **DOT, FHWA, NIST & NSF**
- **Assured Development Security Operations of AI and Autonomous Systems (ADAS) -Trust in Mission Assurance Using Autonomous Apache:** Develops an assurance and trust framework for an autonomous Apache. **Army & TRMC**
- **National AI Research Institutes for Agent-based Cyber Threat Intelligence and Operation:** Seeks to change the way mission-critical systems are protected against sophisticated, ever-changing security threats. **DHS & NSF**
- **Automatic Target Recognition Algorithm Evaluation:** Tailored experiments for performance understanding and robustness to variation in operating conditions. **AFRL**
- **Integrity and Safety of PNT Solutions:** Develops an assurance and trust framework for an autonomous Apache. **AFRL**
- **Assured Neuro Symbolic Learning and Reasoning:** Enables high levels of trust in autonomous systems through new, hybrid AI algorithms. **DARPA**
- **Learning Introspective Control:** Develops machine learning-based introspection technologies that enable physical systems to respond to events not predicted at design time. **DARPA**
- **Transfer from Imprecise and Abstract Models to Autonomous Technologies:** Develops rapid transfer learning techniques to enable same-day autonomy. **DARPA**
- **Center for Excellence on New Mobility and Automated Vehicles:** Provides funding to collect, conduct, and fund research on the impacts of new mobility and highly automated vehicles. **DOT**
- **Highly Automated Systems Safety Center of Excellence:** Provides deep expertise on automation, evaluation and validation for assessing safety implications. **DOT**
- **Cybersecurity:** Secures aviation systems and networks from Global Positioning System spoofing and other attacks. **NASA**
- **Novel and Exceptional Technology and Research Advisory Committee:** Provides recommendations on research involving the use of, and developments in, emerging biotechnologies to the NIH Director. **NIH**
- **Secure AI:** Develops standards, best practices, and testbeds for assessing and managing ML security. **NIST**
- **Secure Software Development Framework:** Develops a framework to incorporate secure-development practices for generative AI and dual-use foundation models. **NIST**
- **Standards Report:** Identifies existing standards, tools, methods, and practices, and potential development of further science-backed and non-proprietary standards and techniques. **NIST**

- **Planning for AI-Ready Test Beds**: Seeks new approaches to develop and evaluate novel artificial intelligence (AI) methods in real-world settings, including the assessment of safety and security. **NSF**
- **Secure and Trustworthy Cyberspace:** Supports research addressing cybersecurity and privacy, drawing on expertise in one or more in areas of computing. **NSF**

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

- **National Artificial Intelligence Research Resource:** Establishes a pilot for a shared national research infrastructure for responsible discovery and innovation in AI. **DOE, NASA, NIH, NIST, NOAA, NSF & industry partners**
- **Open Knowledge Network Initiative:** Develops an interconnected network of knowledge graphs supporting a very broad range of application domains. **NASA, NIH, NIJ, NOAA, NSF & USGS**
- **ADAS – Autonomy and AI Experiment Coordination - Common Operating Picture:** Researches and develops a Human Agent Teaming mobile test harness. **Army, CDAO, Navy & TRMC**
- **ADAS – Collection at the Tactical Edge –Testbed:** Establishes scalable and repeatable data collection capabilities and methods supporting autonomy and AI test events. **Army, CDAO, Navy & TRMC**
- **PDaSP:** Enhances the ability to privately share and analyze data for a range of use cases and applications to solve real world problems. **DOT, FHWA, NIST & NSF**
- **ADAS – COEUS:** Provides a software development platform supporting AI Data Scientists by providing collaboration tools. **CDAO & TRMC**
- **Bridge2AI:** Produces datasets, tools, software, and standards to accelerate the creation of AI/ML-ready datasets and design training materials and activities for workforce development. **NIH & DOE/SC**
- **Research and Engineering AI Hubs:** Shares data, synthetics data generation Modeling & Simulation environments, AI model development, and expertise to solve mission critical problems. **OUSD(R&E) & TRMC**
- **AI Opponent for Contested Space:** Examines the use of ML methods in the role of providing a computer opponent for simulations of future potential contested space scenarios. **AFRL**
- **AI, ML, and Data at DOE Scientific User Facilities:** Advances AI for autonomous control and experimentation, data analysis, and offline design and optimization of scientific user facilities. **DOE/SC**
- **FAIR Data and Models for AI and ML:** Advances AI via data and models that are FAIR, utilizing DOE Public Reusable Research Data initiative and repositories. **DOE/SC**
- **EAR Program:** Ensures broad access to relevant data for highway research, and outreach on data accessibility to Historically Black Colleges & Universities and Minority-Serving Institutions (MSI). **DOT**
- **Path to Advancing Novel Data Analytics:** Explores and solves difficult transportation challenges using emerging analytical tools and approaches. **DOT**
- **Air Traffic Management Data:** Utilizes terabytes of air traffic flight, weather, and traffic flow-related data products for big data analytics and machine learning. **NASA**
- **AIST Program:** Offers competitive solicitation to develop AI and other IT for Earth Science and applications, including disaster response and water resources. **NASA**
- **Earth Science Data Systems Program:** Maximizes the scientific return from NASA's missions and experiments for research and applied scientists, decision makers, and society at large. **NASA**

- **Enterprise Data Platform:** Develops an environment to store and perform analytics on various NASA datasets. **NASA**
- **Science Collaborative for Health disparities and Artificial intelligence bias REduction:** Accelerates research in health disparities, healthcare delivery, health outcomes, and AI bias mitigation strategies. **NIH**
- **Examining the changing dynamics of homicide in Los Angeles:** Applies ML to examine what situational dynamics are driving increase in homicide. **NIJ**
- **Ignitable liquids database and reference collection:** Applies AI and ML techniques in a database containing hundreds of ignitable liquid records. **NIJ**
- **Southern Methodist University's Public Trafficking Project:** Creates a human computational-machine learning game to scrape and complete human trafficking datasets. **NIJ**
- **Best Practices:** Develops best practices for documenting and characterizing datasets and develops datasets for broader community use to test or train AI systems. **NIST**
- **Datasets and Data Resources:** Creates reference datasets, ontologies, taxonomies, and data creation tools supporting research various domains. **NIST**
- **Establish Guidelines and Processes:** Enables developers of generative AI, especially dual-use foundation models, to conduct AI red-teaming tests for deployment of safe, secure, and trustworthy systems as mentioned in the AI EI 14110. **NIST**
- **Frameworks, Testbeds, and Tools:** Develops software testbeds, reference algorithms, and other tools to support fundamental and applied R&D, measurement research, best practices, and standards **NIST**
- **Cyberinfrastructure for Sustained Scientific Innovation:** Enables funding opportunities that are flexible and responsive to cyberinfrastructure for AI research. **NSF**
- **Mid-scale Research Infrastructure:** Supports the design and implementation of research infrastructure including equipment, cyberinfrastructure, large-scale datasets, and personnel. **NSF**
- **National Ecological Observatory Network:** Enables the research community to ask and address questions on environmental challenges. **NSF**
- **Patient-Centered Outcomes Research:** Applies ML techniques to enable health information exchange to support COVID-19. **ONC**
- **AI Patent Dataset:** Makes data available to assist researchers and policymakers focusing on the determinants and impacts of AI invention. **USPTO**

6. Measure and evaluate AI technologies through standards and benchmarks.

- **Central Test and Evaluation Implementation Program (CTEIP) Autonomy, Integration, and Teaming:** Supports aviation domain autonomy test capability emphasizing air range safety of autonomy. **Army, DAF, Navy & TRMC**
- **CTEIP Autonomous Systems Test Capability:** Tests and evaluates capability of hardware integration facilities, modeling and simulation, and live testing of ground and sea domain autonomy. **Army, Navy & TRMC**
- **AACO:** Demonstrates AI-Enabled multi-ship/multi-role Beyond Visual Range (BVR) and Intelligence, Surveillance and Reconnaissance (ISR) combat operations with proficiency. **AFRL**
- **Collection or Reusable Space AI Resources:** Collects AI models for on-demand, within simulation, access using a common simulation framework for both quick reference and evolutionary build-up of models. **AFRL**
- **The AI Task Force program:** Develops and implements a lifecycle management framework for deployed AI capabilities in the context of C2. **AFRL**

- **NCATS' Bias Detection Tools in Health Care Challenge:** Encourages the development of bias-detection and -correction tools that foster "good algorithmic practice". **NIH**
- **Forensic Analysis:** Applies AI and ML techniques for predictive phenotyping, fingerprint aging and identification, drug identification, and age-at-death estimation. **NIJ**
- **Prisoner Assessment Tool Targeting Estimated Risk and Needs:** Enables reviews and revalidation of tools, data, and models for predictive accuracy, as mandated by the First Step Act of 2018. **NIJ**
- **AI Validation and Evaluation:** Launches a new initiative to create guidance and benchmarks for evaluating and auditing AI capabilities, with a focus on capabilities that could cause harm. **NIST**
- **AI Validation and Evaluation:** Develops workshops, evaluations, prize challenges, test beds, and benchmarking approaches for validation and refinement of AI systems. **NIST**
- **Standards Development:** Develops an AI standards hub that will serve as an important resource to support US innovation and competitiveness and develop new industry. **NIST**
- **Trustworthy and Responsible AI:** Expands AI and ML metrics, measurement tools, standards, resources, and testbeds that support fundamental AI R&D and applied use of AI. **NIST**
- **Health Data, Technology, and Interoperability:** Develops certification program updates, Algorithm Transparency, and Information Sharing Health Data, Technology, and Interoperability Proposed Rule towards rulemaking in AI. **ONC**

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 EdW PCA Priority 6.***

- **AFTC Autonomy Data and AI Experimentation Proving Ground working group:** Develops AI T&E academics and AI T&E primers to support workforce upscaling. **AFIT, AFOTEC, AFRL, AFTC & CDAO**
- **DOE Computational Science Graduate Fellowship:** Fosters a community of doctoral students, alumni, DOE laboratory staff and scientists. **DOE/SC & DOE/NNSA**
- **Human Resource Apprentice:** Develops an AI Business Automation partner to assist in the resume review process. **AFRL**
- **NNSA Predictive Science Academic Alliance Program:** Engages with leading U.S. universities, focusing on ways to solve open science and engineering application problems. **DOE/NNSA**
- **DOE Early Career Research Program:** Provides funding opportunities for early-career researchers in universities and DOE national laboratories, with topics in AI. **DOE/SC**
- **FAIR:** Builds research capacity, infrastructure and expertise at institutions historically underrepresented in the Office of Science portfolio. AI-related topics are included. **DOE/SC**
- **Reaching a New Energy Sciences Workforce:** Builds foundations for Office of Science research at institutions historically underrepresented in the SC research portfolio. AI-related topics and traineeships are included. **DOE/SC**
- **Data Science and Transportation Community Building:** Utilizes data science and ML to identify roadway safety issues and address persistent transportation problems in new ways. **DOT**
- **Research Associateship Program:** Provides postdoctoral scientists and engineers to conduct research on problems that are compatible with the research interests of FHWA and contributes to the general research efforts of FHWA. **DOT**
- **AI/ML Consortium to Advance Health Equity and Researcher Diversity (AIM-AHEAD):** Redresses the lack of diversity among AI/ML researchers and lack of representation in AI training data. **NIH**
- **Research Assistantship Program:** Offers highly qualified doctoral students the opportunity to bring their expertise to NIJ to work across offices and program areas to obtain practical and applied research experiences. **NIJ**

- **Develop the AI Workforce:** Participates in federal initiatives for development of AI workforce framework with OPM and other agencies. **NIST**
- **Increase AI Talent at NIST:** Supports NIST associate programs and cooperative research and development projects to inform and augment the NIST technical workforce and extend outreach in AI-related research. **NIST**
- **Student Engagement:** Develops future workforce through NIST student engagement programs, some of which are focused on AI-related disciplines. **NIST**
- **Advancing Education for the Future AI Workforce (EducateAI):** support educators to make state-of-the-art, inclusive AI educational experiences available nationwide. **NSF**
- **Computer Science for All: Researcher-Practitioner Partnership:** Strengthens researcher-practitioner partnerships that foster R&D that bring computer science and computational thinking to all schools. **NSF**
- **CSGrads4US:** Encourages US undergraduates to pursue PhDs in computer science. **NSF**
- **ExLENT:** Aims to provide professionals in any field with an experiential learning opportunity that builds the skills and competencies they need to pivot into careers in key technologies. **NSF**
- **Graduate Research Fellowship Program:** Helps to ensure the quality/vitality and diversity of the scientific & engineering workforce of the U.S. by recognizing & supporting up to 2300 outstanding graduate students annually who are pursuing full-time research-based degrees in STEM. **NSF**
- **Historically Black Colleges and Universities Undergraduate Program:** Enhances undergraduate STEM education & research at HBCUs to broaden participation in the nation's STEM workforce. **NSF**
- **Improving Undergraduate STEM Education:** Enhances the quality of undergraduate STEM education & increases the recruitment/retention and graduation rates of students pursuing degrees in STEM at Hispanic Serving Institutions. **NSF**
- **NSF Entrepreneurial Fellowships:** Helps make entrepreneurship more accessible for people in less-developed innovation ecosystems, expanding diversity and increasing participation of women & others underrepresented in STEM. **NSF**
- **Research on Innovative Technologies for Enhanced Learning:** Supports early-stage research in emerging technologies for teaching and learning that responds to pressing needs in authentic educational environments. **NSF**
- **Tribal Colleges and Universities Undergraduate Program:** Supports tribal colleges/universities, Alaska and Hawaiian-serving institutions to promote STEM research and education to increase the number of Native Americans in STEM careers. **NSF**
- **Public Health Informatics & Technology Workforce Development Program:** Aims to train more than 5,000 individuals over a four-year period in public health informatics and technology. **ONC**
- **1890 Institution Teaching, Research and Extension Capacity Building Grants:** Builds the institutional teaching, research, and extension capacities of the eligible institutions. **USDA-NIFA**
- **Education and Workforce Development Program:** Supports professional development opportunities for all students and educational professionals by providing workforce training across educational institutions. **USDA-NIFA**
- **Food and Agricultural Non-Formal Education:** Supports content development and activities for non-formal education to foster development of technology-savvy youth. **USDA-NIFA**
- **Hispanic-Serving Institutions Education Grants Program:** Attracts students and produces graduates to enhance the nation's food and agricultural scientific and professional workforce. **USDA-NIFA**

- **National Needs Graduate and Postgraduate Fellowship Grants Program:** Supports graduate student training and completion of degree in identified areas within the food and agricultural sciences. **USDA-NIFA**
- **Predoctoral and Postdoctoral Fellowships:** Cultivates future leaders who can solve emerging agricultural challenges. **USDA-NIFA**
- **Research and Extension Experiences for Undergraduates:** Promotes research and extension learning experiences for undergraduates such that upon graduation they may enter the agricultural workforce with exceptional skills. **USDA-NIFA**
- **Women and Minorities in Science, Technology, Engineering, and Mathematics:** Supports research, and education/teaching that increase participation by women and underrepresented minorities from rural areas in STEM. **USDA-NIFA**
- **Patent Examiner Technical Training Program:** Promotes voluntary assistance from experts from industry and academia to provide technical training and expertise to patent examiners. **USPTO**
- **USPTO's AI Resource Portal:** Develops and delivers robust AI training offerings and provides broad access to training throughout the USPTO. **USPTO**

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.

- **Digital Synthetic Range:** Creates an operational assessment ability for industry partners interfacing with DOD networks in a digital environment. **DAF & TRMC**
- **NSF Regional Innovation Engines:** Serves as a catalyst and fosters innovation ecosystems across the U.S. to positively impact the economy within a geographic region, address societal challenges, and advance national competitiveness. **NSF & regional partners**
- **Resilient and Intelligent Next Generation Systems (RINGS):** Supports the research on emerging NextG wireless and mobile communication, networking, sensing, and computing systems, along with global-scale services. **NSF & industry partners**
- **Small Business Innovation Research (SBIR)/STTR & Cooperative Research and Development Agreement:** Develops AI S&T solutions for Space. **AFRL**
- **Have RUNners Networked Edge Range:** Advances flight test modernization to enable real-time AI development. **DAF**
- **Advancing AI:** Co-designs and procures hardware, testbeds, and systems, and evaluates open and closed AI/ML models and datasets. **DOE/NNSA**
- **AI City Challenge at Computer Vision and Pattern Recognition:** Applies AI to improve the efficiency of operations in all physical environments. **DOT**
- **NASA Small Business Technology Transfer (STTR):** Develops AI/ML-based digital assistants for use onboard for missions and on ground for all facets of R&D. **NASA**
- **Leadership Scholars Program within AMP AIM:** Supports Leadership Scholars in Accelerating Medicines Partnership® Autoimmune and Immune-Mediated Diseases (AMP® AIM) programs to work with researchers. **NIH**
- **Advance Measurement Science:** Works with the broad stakeholder community to conduct evaluations, develop best practices and test methods, and contribute to voluntary consensus-based standards activities for measuring and evaluating AI. **NIST**
- **Generative AI Public Working Group:** Builds on efforts in Generative AI Public Working Group to spearhead the development of a cross-sectoral AI RMF profile. **NIST**
- **Measure and Evaluate AI:** Engages with the private sector, academia, and civil society as it produces guidance as per the AI EO 14110. **NIST**

- **Secure Trustworthy AI at the NIST National Cybersecurity Center of Excellence:** Works with industry partners in laboratory environment to demonstrate secure and trustworthy AI capabilities. **NIST**
- **Specification and Best Practices:** Develops and refines specifications for effective nucleic acid synthesis procurement screening, best practices, including security and access controls, for managing sequence-of-concern databases. **NIST**
- **TRAILS:** Integrates participatory design, technology, and governance of AI systems and technologies and will focus on investigating what trust in AI looks like. **NIST**
- **U.S. AISI:** Establishes the institute and a Consortium to create safe and trustworthy artificial intelligence (AI) through collaborative measurement science. **NIST**
- **Participating in the Coalition for Health AI:** Defines core principles and criteria to evaluate, monitor and report health AI systems throughout their lifecycle. **ONC**
- **Participating in the Health AI Partnership:** Develops guidance for healthcare professionals using AI and related emerging technologies. **ONC**
- **Defense Technology Review:** Organizes a conference on AI and Autonomy technology review to discuss the state of the art and future of the technology area. **OUSD(R&E)**
- **Engineering for Agricultural Production and Processing:** Develops AI to enable innovation and discovery to equitably meet producer needs and perceptions. **USDA-NIFA**
- **AI-Emerging Technology (ET) Partnership:** Promotes awareness, openness, and inclusivity on leveraging AI/ET to serve stakeholders and foster public trust. **USPTO**

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

- **AUKUS Partnership:** Accelerates adoption, and improving interoperability, scalability, and resilience of, autonomous and AI-enabled systems in contested environments. **Army, DAF, Navy, OUSD(R&E) & international partners**
- **Bi-lateral Engagements**: Collaborates with UK on AI evaluation, AI technical standards, AI security, and privacy-preserving prize challenges including the PETs Challenge in a US-UK collaboration to foster privacy-preserving data access and use. **DOE/SC, NAIIO, NIST, NSF & international partners**
- **AI for Multi-environment Situational Awareness:** Advances multi-sensor fusion, multi-object tracking, and multi-platform collaborative data collection in a multi-domain environment. **Army, Navy, OUSD(R&E) & international partners**
- **Collaborative Research in Computational Neuroscience:** Supports collaborative international research and data-sharing research in AI that will advance the understanding of nervous system structure and function. **NSF, NIH, DOE & international partners**
- **Education Cooperation**: Supports a Memorandum of Understanding with Japan Ministry of Education, Culture, Sports, Science and Technology. **DOE/SC, DOE/NNSA & international partner**
- **Multi-modal Active Perception System:** Develops and use AI-enabled assessment of building damage and human casualty presence. **Army, OUSD(R&E) & international partners**
- **Accelerated Data Analytics and Computing Institute:** Explores research in computing and data through a Memorandum of Understanding with international high-performance computing organizations. **DOE/SC & international partners**
- **AI Policy Contributions:** Convenes national and international stakeholders to ensure two-way communication on select AI-related issues. **NIST & international partners**

- **Convergence Accelerator (Track I: Sustainable Materials for Global Challenges):** Funds the development of fundamental materials science, including materials design & manufacturing processes, and circular design to create environmentally/economically/sustainable materials and products. **NSF & international partner**
- **Convergence Accelerator (Track L: Real-World Chemical Sensing Applications):** Funds the development of tools/technologies/applications to advance olfaction/biosensing/chemical sensing solutions. **NSF & international partner**
- **Harnessing Data Science for Health Discovery and Innovation in Africa:** Advances data science health research and innovation in Africa. **NIH & international partners**
- **Responsible and Equitable AI under the U.S. National Science Foundation (NSF) and the Australian Commonwealth Scientific and Industrial Research Organisation:** Brings together U.S. and Australian researchers on responsible and Equitable AI through the transmittal of a Dear Colleague Letter. **NSF & international partner**
- **Standards Development:** Coordinates with international partners to drive the development and implementation of AI-related consensus standards, cooperation, and information sharing. **DOC & NIST**
- **Trillion Parameter Consortium:** Improves large-scale generative AI models aimed at tackling complex scientific challenges. **DOE & international partners**
- **UtiliZing health Information for Meaningful impact in East Africa through Data Science:** Uses health data and advanced AI/ML methods to create early warning systems for critical health issues affecting young Africans. **NIH & international partners**
- **Accelerating Fusion, High Energy Physics, and Nuclear Physics:** Supports a Memorandum of Understanding with France Alternative Energies and Atomic Energy Commission. **DOE/NNSA**
- **Atomic Weapons Research:** Supports a Mutual Defense Agreement with UK Atomic Weapons Establishment. **DOE/NNSA**
- **US-European Union AI Administrative Arrangement:** Advances AI to improve health, medicine, electric grid, and other topics through US-EU AI collaboration. **DOE/SC**
- **Organization for Economic Cooperation and Development:** Supports a repository for AI metrics. **NIST**
- **Quadrilateral Security Dialogue Standards Sub-group:** Fosters strategic security dialogue between the U.S., India, Japan, and Australia. **NIST**
- **Trade and Technology Council Technology:** Develops a roadmap for AI risk management approaches. **NIST**
- **Participation in the Global Digital Health Partnership:** Supports the executive implementation of worldwide digital health services. **ONC**

3.0 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: DOC/NIST, HHS (NIH, NIOSH) & NSF

3.1 Strategic Priorities & Associated Key Programs/Activities

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.

- **Evaluating Generative AI Technologies:** Supports developing an evaluation series to research the risks, harms, and impacts of synthetic content in generative AI. **NIST**
- **Immersive Collaboration Environments:** Supports the ParaView tool for collaborative data analysis in immersive environments with local and remote users. **NIST**
- **Trustworthy and Responsible Artificial Intelligence Resource Center:** Expands an online forum to support and operationalize the NIST AI Risk Management Framework, offering centralized access to tools, metrics, and resources. **NIST**
- **Usability and Human Factors research:** Understands and measures human interaction with information technology, providing guidance for better design and use. **NIST**
- **Convergence Accelerator (Track B: AI & the Future of Work):** Funding solutions to train, reskill, and upskill the current and future workforce with industry needs and jobs of the future, as well as build a talent pipeline to stimulate the U.S. workforce. **NSF**
- **Convergence Accelerator (Track H: Enhancing Opportunities for Persons with Disabilities):** Bringing together a wide range of disciplines and sectors to develop sustainable use-inspired new technologies and tools to enhance quality of life and employment access and opportunities for persons with disabilities. **NSF**
- **Human-Centered Computing:** Supports interdisciplinary research in human-computer interaction to design technologies that enhance human capabilities & study their benefits, effects, & risks. **NSF**
- **Research on Innovative Technologies for Enhanced Learning**: Supports early-stage research in AI, robotics, and immersive tech to address real-world educational needs. **NSF**
- **Science of Learning and Augmented Intelligence:** Supports research on learning principles and augmented intelligence—enhancing human cognition through interactions with technology. **NSF**
- **Smart and Connected Communities:** Supports research addressing community challenges by integrating intelligent technologies into natural and built environments. **NSF**

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

- **Mind, Machine and Motor Nexus**: Supports fundamental research exploring embodied reasoning as mediated by bidirectional sensorimotor interaction between human and synthetic actors. **NSF**

4.0 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.

4.1 Computing-Enabled Networked Physical Systems IWG

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.

Agencies: Army (JST), DHS, DOC (ITA, NIST, USPTO), DOD (DARPA, NSA), DOE, DOT (FHWA, NHTSA), FDA (CDRH, OSEL), HHS/NIH, OSHA, NASA, NSF, State & USDA-NIFA

4.1.1 Strategic Priorities & Associated Key Programs/Activities

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

- **Cyber Physical Systems Program:** Develops cross-cutting, fundamental scientific & engineering principles that underpin the integration of cyber & physical elements. **DOT, DHS, NIH, NSF & USDA-NIFA**
- **Catalog of Regulatory Science Tools:** Collates a variety of regulatory science tools that the FDA's CDRH developed and plans to expand as new tools become available. **CDRH & OSEL**
- **Deep Generative Modeling for Learning Medical Image Statistics:** Invites participants to develop generative models that reproduce image statistics to medical imaging applications. **CDRH & OSEL**
- **Pipelined Reasoning of Verifiers Enabling Robust Systems (PROVERS):** Develops automated, scalable formal methods tools for integrating high-assurance systems into traditional software development. **DARPA**
- **Genomics Research and Innovation Network:** Implements global scalable technology, procedures for bio samples associated genomic & phenotypic data. **NIH**
- **NIH Cloud Platform Interoperability Initiative:** Seeks to create a federated data ecosystem and is a collaborative project between NIH and external partners. **NIH**
- **Asynchronous Byzantine Fault Tolerance:** Utilizes distributed ledger records for operational and post mission event analysis including T&E of probabilistic system ops. **NSA**
- **Formal Methods and Tools:** Explores scalable and rigorous approaches to detecting, identifying, and influencing emerging behavior for complex future systems. **NSA**
- **Resilient operations in contested environments:** Operates resilience in contested environments by adapting a decentralized global network to mission scale within GPS-denied areas. **NSA**
- **Agriculture and Food Research Initiative (AFRI):** Focuses on data science, improve resource management, & integrate new technological approaches to further U.S. food & agriculture. **USDA-NIFA**

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

- **Civic Innovation Challenge:** Accelerates S&CC research & information sharing across sectors and lays the groundwork for research & scientific discovery. **DHS, DOE, NSF & USDA-NIFA**
- **S&CC:** Accelerates the creation of scientific and engineering foundations that will enable S&CC to bring economic opportunity and growth, safety, security, and health and wellness. **DOT, NSF & USDA-NIFA**

- **Smart Health and Biomedical Research in the Era of AI and Advanced Data Science:** Supports transformative advances in CISE research in the biomedical and public health communities. **NIH & NSF**
- **Resilient Investment, Planning and Development Working Group:** Addresses cyber-physical infrastructure resilience concerning equity and underserved communities. **DHS**
- **The Resilience Science and Technology Grand Pathways Framework:** Provides an opportunity for resilience through measured investment and collaboration that is outcome-based. **DHS**
- **Automated Vehicles Measurement Science:** Develops infrastructure, test methods, and metrics for automated vehicles to advance system level measurement and testing. **NHTSA**
- **Operational Technology (OT) Security:** Provides guidance on how to improve the security of OT systems while addressing their unique performance, reliability, and safety requirements. **NIST**
- **CISE Core Programs:** Supports projects that develop knowledge of (CISE) and advanced cyberinfrastructure elements of CNPS systems. **NSF**
- **Civil, Mechanical & Manufacturing Innovation Core Programs:** Supports civil infrastructure research that contributes to creating smart, sustainable and resilient communities at all scales. **NSF**
- **Formal Methods in the Field:** Aims to bring researchers in formal methods of CISE to develop rigorous methodologies for designing and implementing construction systems and applications. **NSF**
- **Industry-University Cooperative Research Centers:** Generates breakthrough research by enabling close and sustained engagement of industry, academia, and government agencies. **NSF**

3. Promote inclusive education, training, and career development through curricula that integrates CNPS and by providing venues for communications and collaboration among scientists and researchers. See the EdW PCA for education, training, and career development related activities. Also see EdW PCA Priority 8.

- **Exploratory Advanced Research Program:** Provides postdoctoral scientists and engineers with an opportunity to conduct research on The Turner-Fairbank Highway Research Center. **DOT**
- **Characterization of Chronic Pain and its Biopsychosocial Mechanisms in Lupus:** Uses computational methods to increase the understanding of chronic pain of Lupus using electronic health records (EHR). **NIH**
- **Enhancing individualized care for Alzheimer's Disease and Diabetes:** Features a research project of systematic approaches to a comprehensive plan in improving care of Alzheimer's disease, related dementias, and diabetes mellitus. **NIH**
- **Improving Treatment Engagement in Individuals with Substance Use and Psychosis:** Provides guidance to address treatment, telemedicine, clinical intervention research, & development. **NIH**
- **Neural Network Approach to Estimate Fetal Weight (EFW)**: Improves the accuracy of EFW calculation to aid in decision-making for obstetricians and decrease perinatal complications. **NIH**
- **Scalable mHealth Resource to Facilitate Behavioral and Emotional Recovery after Pediatric Traumatic Injury:** Develops, tests, and scales innovative technology resources to improve those impacted by pediatric traumatic injury. **NIH**
- **National Initiative for Cybersecurity Education (NICE)**: Energizes and promotes a robust network and an ecosystem of cybersecurity education, training, and workforce development. **NIST**
- **Broadening Participation Portfolio:** Focuses on key investments that range from research centers, partnerships, and alliances to the use of co-funding in the core research programs. **NSF**
- **CISE Education and Workforce Program:** Transforms computing education on a national scale to meet the challenges and opportunities essential to all sectors of society. **NSF**

- **CyberCorps® Scholarship for Service:** Supports scholarships in cybersecurity designed to increase the number of qualified and diverse cybersecurity candidates for government cybersecurity positions (requires a service obligation following graduation equivalent to the length of the scholarship). **NSF**
- **ExLENT:** Aims to provide professionals in any field with an experiential learning opportunity that builds the skills and competencies they need to pivot into careers in key technologies. **NSF**
- **NSF Entrepreneurial Fellowships:** Helps make entrepreneurship more accessible for people in less-developed innovation ecosystems, expanding diversity and increasing participation of women and others underrepresented in STEM. **NSF**
- **AFRI Education and Community Development Program**: Focuses on education and workforce development for field and industrial jobs within the food and agricultural sciences. **USDA-NIFA**
- **AFRI Foundational Economic and Social Implications of Food and Agriculture:** Assesses impacts that a broad range of emerging and disruptive technologies pose for agricultural markets. **USDA-NIFA**

5.0 Cyber Security and Privacy (CSP) PCA

CSP R&D advances the security, resilience, trustworthiness, 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.

5.1 Cyber Security and Information Assurance (CSIA) IWG

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.

Agencies: Army (ARL, ARO, C5ISR), DAF/AFRL, DHS, DOC/NIST, DOD (DARPA, HPCMP, NSA, OUSD(R&E), USCYBERCOM), DOE, DOJ/NIJ, DOT, GSA, HHS/NIH, Navy (NRL, ONR) & NSF

5.1.1 Strategic Priorities & Associated Key Programs: Research Priorities (1-9) & Federal Priority Application Scenarios (10-12)[1]

This section provides the main lines of research pursued by those programs, mapped against the CSIA strategic priorities. The programs are listed in the accompanying FY2025 Federal Cybersecurity R&D Strategic Plan Implementation Roadmap.[2] The following are the CSIA IWG's strategic priorities and relevant programs.

1. Cybersecurity Through Human-centered Approaches: Develop capabilities to effectively incorporate human and societal values, needs, and abilities into the design, development, operation, and evaluation of information systems and cybersecurity solutions.

- **Trust and Influence (Basic research):** Develops science of trust for human-machine teaming and ways to protect humans from information-based threats. **AFRL**
- **Human AI Teaming for Cybersecurity:** Explores how AI (and other tools) can be used to make humans more effective, while understanding the risks and challenges to inform best practices. **DHS**

[1] See federal cybersecurity R&D strategic priorities in https://www.nitrd.gov/pubs/Federal-Cybersecurity-RD-Strategic-Plan-2023.pdf
[2] https://www.nitrd.gov/pubs/FY25-Cybersecurity-Implementation-Roadmap.pdf

- **Human-Centered Cybersecurity:** Conducts research projects to understand usability and the human element in cybersecurity. **NIST**
- **Human Machine Teaming for Software Analysis (Centaur):** Develops advanced software analysis environments for automated analysis of binaries, and tools interoperability. **NSA**
- **Secure and Trustworthy Cyberspace (SaTC) Program & Cybersecurity Innovation for Cyberinfrastructure (CICI) Program:** Advances research in applying behavioral and social science knowledge, methods, and theory to tackle threats to cybersecurity. **NSF**
- **Dominating Information using Stealthy Resilient Unblockable Protocol Transformations:** Develops capabilities to integrate societal values into IT systems. **ONR**
- **Holistic software debloating using large language models:** Explores ML/AI methods to raise the effectiveness of human interactions and participation in software debloating. **ONR**

2. Empower Organizations to Tackle Cybersecurity Threats: Develop methods, techniques to understand, analyze, and manage cyber security, cyber resilience, and privacy risks. Advance methods and techniques to understand how markets, liabilities, incentives, insurance, and regulation could ensure better cyber security and cyber resilience outcomes.

- **Develop and Deploy Program:** Provides resources to trade associations to facilitate deployment of sensors, tools, and cyber capabilities to small and medium-sized electricity asset owners. **DOE**
- **SaTC and CICI Programs:** Research to analyze the role of commercial system on the spread of misinformation research to improve organizational security practices and technology. **NSF**
- **AI-enabled and Autonomic Cyber Operations:** Develops capabilities to effectively understand attacks and cybersecurity posture with machine-speed reasoning. **ONR**

3. Cybersecurity Education and Workforce Development: Advance programs in cybersecurity education, training, professional development, and public awareness. Develop capabilities to improve the productivity of the cybersecurity workforce.

- **Virtual Institutes for Cyber and Electromagnetic Spectrum Research and Employ:** Establishes cyber security curriculum involving 44 universities across the nation. **AFRL, ARL, NRL & OUSD(R&E)**
- **Advance Course in Engineering:** Provides a 10-week cybersecurity internship. **AFRL & NSA**
- **NIH Data Path:** Provides a 2-year internship program to develop early-career talents in cybersecurity and NIH operations. **GSA & NIH**
- **Internet of Things Cybersecurity Training for Law Enforcement:** Develops cybersecurity training with a focus on "Internet of Things" devices and their forensic impacts in investigations. **DHS**
- **Virtualized Industrial Control System (ICS) Testbed for Research, Training, and Education:** Develops a fully virtualized ICS testbed, replicating real-time hardware interactions and unprecedented fidelity. **DHS**
- **University-Based Cyber R&D Programs:** Establishes academic collaboration centers to innovate & transition capabilities that reduce the risk of power disruption caused by a cyber-incident. **DOE**
- **National Centers of Academic Excellence in Cybersecurity:** Establishes standards for cybersecurity curriculum and academic excellence. **NSA**
- **AI Scholarship For Service:** Develops higher education program to produce graduates with education related to AI, modeled after CyberCorps® Scholarship For Service (SFS) program. **NSF**
- **CyberCorps® SFS:** Recruits and trains the next generation of information technology professionals. **NSF**
- **ExLENT:** Aims to provide professionals in any field with an experiential learning opportunity that builds the skills and competencies they need to pivot into careers in key technologies. **NSF**

- **NSF Entrepreneurial Fellowships:** Helps make entrepreneurship more accessible for people in less-developed innovation ecosystems, expanding diversity and increasing participation of women & others underrepresented in STEM. **NSF**
- **Science of cyber warrior training:** Develops scientific understanding of how to most effectively train people for cyber operator positions for national security missions. **ONR**
- **University Consortium for Cybersecurity (UC2):** Supports academic cybersecurity research and education in a consortium of universities established to assist the Secretary of Defense. **OUSD(R&E)**

4. Establish and Negotiate Trust: Develop capabilities to establish, enforce, and verify the desired level of trust at all layers of computing (e.g., hardware, operating systems, applications, networking, information exchanges). Develop capabilities to establish and ensure trust for identity, access, and interoperation.

- **Tactical Zero Trust:** Develops zero trust capabilities for network defense at the tactical edge. **C5ISR**
- **Cerberus-Guarding Sensitive Data with Trigeneous Secure Computations:** Approaches that combine different types of secure computations with provable security guarantees. **DHS**
- **Privacy Enhancing Technologies:** Characterizes and evaluates advanced and emerging privacy enhancing technologies. **DHS**
- **NIH Researcher Auth Service:** Develops centralized authentication, authorization, and audit service for the federated NIH data ecosystem. **NIH**
- **Identity and Access Management:** Develops digital identity guidelines for modern digital identity controls. **NIST**
- **Security Systems Architecture/Analyses:** Develops tools and techniques to validate trusted behavior and design of systems. **NSA**
- **Convergence Accelerator (Track G: Securely Operating Through 5G Infrastructure):** Funds solutions to enhance end devices and/or augmentations to 5G infrastructure to enable operators the capability to operate through public 5G networks, while meeting security/resilience requirements. **NSF**
- **SaTC and CICI Programs:** Advances research to establish trust within wireless networks, in information ecosystems, and through software security engineering methods. **NSF**
- **Unmanned system swarms:** Develops capabilities to detect deep fakes in military environments. **ONR**
- **Intel ICX-D 3U VPX Security Enhancement:** Accelerates the use of advanced security capabilities within Intel ICX-D processor in support of deployments requiring higher-level security. **OUSD(R&E)**

5. Cyber Resilience by Design: Develop methods and approaches for designing, developing, and validating systems that can withstand and recover from cyberattacks and continue to deliver vital functions even when compromised. Advance science and engineering of cyber resilience.

- **Ecosystem for Cyber Analytics:** Leverages high-performance computing to explore cybersecurity analytical capabilities. **HPCMP, ONR, OUSD(R&E) & USCYBERCOM**
- **Blue Phyzzing:** Develops dynamic analysis tools for continuous development and energy industries. **AFRL & OUSD(R&E)**
- **Critical-infrastructure Hardening Achieved through Risk-reduction in Informational and Operational Technology:** Conducts testing of ICS in rail and energy industries. **DHS & DOT**
- **Core T-CORE Secure Processor:** Supports the development of new processor architecture that provides hardware protection against execution of vulnerable software. **AFRL**

- **Quantitative Measurement of Cyber Resilience:** Investigates quantitative measurements of cyber resilience. **ARL**
- **Hardening Development Toolchains Against Emergent Execution Engines:** Mitigates emergent behaviors in computing systems throughout the entire software development lifecycle. **DARPA**
- **Pipelined Reasoning of Verifiers Enabling Robust Systems:** Develops formal methods tools to guide software engineers through designing proof-friendly software systems. **DARPA**
- **Verified Security and Performance Enhancement of Large Legacy Software:** Enables software development that is both correct-by-construction and compatible-by-construction. **DARPA**
- **Resilience of Software Analysis Models:** Approaches for increasing the resilience of ML algorithms to adversarial attacks, in the context of the DHS missions. **DHS**
- **Cyber RD&D Program:** Develops tools and technologies that improve the security and resilience of today's energy delivery systems through a cybersecurity-by-design approach. **DOE**
- **Software Security Development Framework:** Develops and maintain guidelines for best practices in secure software development. **NIST**
- **SaTC and CICI Programs:** Advances research to harden hardware, software, network, system, and critical infrastructure security. **NSF**
- **Self-Healing Ship Concepts:** Develops technologies and capabilities to increase redundancies and resiliency of computing and networking systems on ships. **ONR**

6. Deter: Develop capabilities to efficiently discourage malicious cyber activities by increasing costs, diminishing the spoils of, and increasing risks and uncertainty for potential adversaries.

- **Cryptography:** Advances foundations of cryptography by leveraging phenomena from quantum physics. **AFRL**
- **Camouflage and Decoy of cyber and electromagnetic activities for Network Survivability:** Develops adaptive cyber deception methods while maintaining effective communications. **ARL**
- **Cyber Deception Multidisciplinary University Research Initiative:** Develops a framework of deception methods to successfully manipulate adversaries' mental state. **ARO**
- **Signature Management using Operational Knowledge and Environments:** Develops data-driven tools to automate the planning and execution of threat-emulated cyber infrastructure. **DARPA**
- **Criminal Investigations and Network Analysis Center of Excellence:** Supports academic consortium that addresses key challenges in criminal investigations. **DHS**
- **Fleet Vehicle Cybersecurity:** Supports research on cybersecurity threats to vehicles used by DHS components in law enforcement operations requiring enhanced cybersecurity. **DHS**
- **Cryptography:** Advances solutions and standards in post-quantum cryptography, lightweight cryptography, multi-party threshold cryptography, and privacy-enhancing cryptography. **NIST**
- **Adaptive Cyber Deception:** Advances network decoy prototype, which serves as a high-confidence tripwire and platform for researching the effectiveness of deception. **NSA**
- **SaTC Programs:** Advances research to create effective and deployable techniques and strategies that will offer resiliency in networks and computing systems, and reduce the impact and likelihood of success of adversarial attacks**. NSF**

7. Protect: Develop technologies to limit system vulnerabilities through design, construction, and verification, where components, systems, users, and critical infrastructure can efficiently resist malicious cyber activities and can ensure confidentiality, integrity, availability, and accountability.

- **Counterfeit Mitigation in Microelectronics Supply Chain:** Designs an end-to-end capability for establishing supply chain integrity and provenance of electronic chips. **DHS & NIST**
- **Critical Infrastructure Resiliency and Prediction of Cascading Effects:** Provides predictive analysis to increase resilience of critical infrastructure. **AFRL**
- **Predictive Intelligent Networking:** Develops resilient and adaptive network configurations that allow continued secure communications. **C5ISR**
- **Public Key Infrastructure (PKI) Modernization:** Supports research focuses on modernizing the PKI in tactical environments. **C5ISR**
- **Business Process Logic:** Develops tools to identify logic faults and vulnerabilities in business systems that control and manage defense-critical workflows such as manufacturing, and logistics. **DARPA**
- **Open, Programmable, Secure 5G:** Pursues research leading to the development of a portable standards-compliant network stack for 5G mobile that is open source and secure by design. **DARPA**
- **Adversarial Machine Learning/AI Robustness:** Develops ML model resiliency capabilities that will protect DHS models from Adversarial Machine Learning attacks. **DHS**
- **Open-Source Software Security:** Develops an end-to-end methodology to allow organizations to identify all devices and software in their systems and output a software bill of materials (SBOM). **DHS**
- **Software Assurance and Data Protection:** Develops data bill of materials, enhanced software assurance techniques, and software analysis technologies. **DHS**
- **Cyber RD&D Program and University-Based R&D Program:** Develops solutions to decrease the cyber-attack surface of energy delivery systems and components. **DOE**
- **Operationalizing the Cybersecurity Framework:** Develops data-driven modeling and engineering to automate analysis in the context of the NIST Cybersecurity Framework. **HPCMP**
- **Cybersecurity Framework:** Develops guidance on qualitative and quantitative assessments of cybersecurity and privacy risks, in the context of the NIST Cybersecurity Framework. **NIST**
- **5G and Future NextG Cybersecurity Research:** Contributes world class cybersecurity enhancements to 5G Standards Bodies. **NSA**
- **Security-Enhanced Linux (SELinux) Policy Development and Orchestration:** Matures the SELinux Policy Language for the creation of Mandatory Access Control policies in SELinux. **NSA**
- **SaTC and CICI Programs:** Advances research in hardware, software, and networking security and effective techniques to protect software and hardware supply chain. **NSF**
- **Memory-safe languages:** Develops automated translation to memory-safe languages; explore dynamic analysis techniques to provide additional security guarantees. **ONR**

8. 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.

- **AI Institute for Agent-based Cyber Threat Intelligence and Operation Institute:** Develops AI-based agents to identify flaws, detect attacks, and respond to breaches. **NSF & DHS**
- **Automated Vulnerability Identification Prioritization for Embedded Resources:** Researches and develops novel automated approaches to detecting vulnerabilities in source code. **AFRL**

- **Salient Ghost Phase 2:** Supports research methods to analyze code for errors that could produce vulnerabilities. **AFRL**
- **Intelligent Generation of Tools for Security:** Develops new techniques driven by program analysis and artificial intelligence to measure vulnerabilities within modern, complex systems. **DARPA**
- **Cyber Machine Learning:** Develops AI-based analytics for cybersecurity problem-solving, including AI tools for automating analysis and response tasks. **DHS**
- **Cyber RD&D Program and University-Based R&D Program:** Develops solutions to detect attempts to execute unwanted functionality in the energy delivery systems. **DOE**
- **Cybersecurity Environment for Detection, Analysis, & Reporting:** Cyberspace operation platform to detect network traffic threats to Defense Research & Engineering Network. **HPCMP**
- **Data Fusion and Large-Scale Graph Analytics:** Enables situational understanding of events from diverse and disparate data sources. **NSA**
- **CICI Program/Scalable Vulnerability Discovery and Mitigation on "Big Binaries":** Develops technologies capable of finding and mitigating vulnerabilities in legacy binaries. **NSF**
- **SaTC Program/Hardware Security-Tempering Detection:** Detects chip tampering without destroying the semiconductor packaging. **NSF**
- **Detection research:** Develops methods to improve threat detection using hyper dimensional computing and to defend network assets at 100Gbps and beyond. **ONR**

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

- **Cyber Agents for Security Testing and Learning Environments:** Instantiates realistic network environments and train AI agents in the defense against advanced persistent cyber threats. **DARPA**
- **Cyber Machine Learning:** Develops AI-based analytics ecosystem for cybersecurity problem-solving, including AI tools for automating analysis and response tasks. **DHS**
- **Cyber RD&D Program and University-Based R&D Program:** Develops technologies to enable energy sector to survive a cyber-incident while sustaining critical functions. **DOE**
- **Guidelines for response:** Develops guidelines and best practices on how to prevent and recover from data breachers, ransomware attacks, and other destructive events. **NIST**
- **Autonomous Cyber Defense Response:** Develops an autonomous cyber defense system that reasons and responds to mitigate the effects of advanced cyber-attacks at machine speed. **NSA**
- **SaTC Program/satellite network security:** Develops technologies to secure networks for satellite systems. **NSF**
- **BotRaids:** Explores new approaches for disrupting botnets through the adversary's command and control capabilities. **ONR**

10. Protect Software and Hardware Supply Chain: Develop capabilities to attest to Software and Hardware supply chain integrity through design and development, and to verify and maintain ongoing supply chain integrity throughout operations.

- **Enhanced SBOM for Optimized Software Sustainment:** Develops enhanced software bill of material technology to enable rapid remediation of vulnerabilities in software at scale. **DARPA**
- **Software Supply Chain Visibility Tool:** Energizes the market to provide SBOM capabilities for the enterprise, system administrators, and software developer communities. **DHS**
- **Cybersecurity Supply Chain Risk Management:** Develops guidelines and best practices for securing the cybersecurity supply chain. **NIST**
- **Hardware and Software supply chain protections:** Detects and prevents targeted Trojan insertion by untrusted foundry and develop low-cost authentication to verify IC circuits. **NSF**

- **Hardware and Software supply chain protections:** Develops capabilities to detect attacks and to assure integrity of software development methods and integrity of computer chips. **ONR**

11. Realize Secure and Trustworthy Artificial Intelligence: Develop capabilities to realize AI that is verifiably safe, secure, and resilient. Provide capabilities that improve trusted collaboration between humans and AI.

- **Augmented Cyber Cognition with Operational Learning Automation of Deployable Expertise:** Develops assistive automation capabilities for cyber operators. **AFRL, ARL, NRL & OUSD(R&E)**
- **Autonomous Active Cyber Defense:** Develops scientific understanding of robust learning under adversarial conditions to autonomously defend enterprises and cyber physical systems. **ARL & ARO**
- **TrojAI:** Detects trojans in AI/ML systems. **ARO & IARPA**
- **Trustworthy AI research:** Advances science and technology to secure AI, to use AI for better cybersecurity, and to defend against AI-based attacks. **NSA & NSF**
- **Probabilistic and Differentiable Programming:** Advances structural foundations for probabilistic and/or differentiable programs. **AFRL**
- **Cyber Machine Learning:** Develops AI-based analytics for cybersecurity problem-solving, including AI tools for automating analysis and response tasks. **DHS**
- **Cyber RD&D Program and University-Based R&D Program:** Develops technologies that use control system data and AI algorithms to automatically respond to threats to energy systems. **DOE**
- **AI Safety Institute:** Advances the science of AI safety; articulates, demonstrates, and disseminates the practices of AI safety; and supports institutions, communities, and coordination around AI safety. **NIST**
- **NSF Regional Innovation Engines:** Acts as a catalyst for innovation across the U.S., boosting regional economies, tackling societal challenges, and enhancing national competitiveness through AI applications in areas like mobility, climate-resilient food production, and cybersecurity. **NSF**
- **Foundation Models for Automatic Generation of Correct-by-Construction Code:** Develops a novel framework for the automated generation of correct-by-construction code at scale. **ONR**

12. Secure Clean Energy Future: Develop capabilities to ensure that clean energy technologies and systems are inherently secure and resilient to cyber or cyber-physical threats.

- **Convergence Accelerator (Track I: Sustainable Materials for Global Challenges):** Funds the development of fundamental materials science, including materials design and manufacturing processes; and circular design to create environmentally/economically/sustainable materials and products. **NSF & international partners**
- **All Hazards Energy Resilience:** Develops technologies to increase resilience and reduce risks to energy delivery infrastructure from a variety of hazards, including cyber and physical threats. **DOE**
- **Clean Energy Distributed Energy Resources program:** Enables National Laboratories in cybersecurity tools and technologies for clean energy distributed energy resources. **DOE**
- **AV/EV Vehicle Charging Security and Privacy:** Develops guidance and best practices for improving the security and privacy of the electric vehicle charging infrastructure. **NIST**
- **Convergence Accelerator (Track K: Equitable Water Solutions):** Leverages foundational knowledge/advancements in various fields to fund practical, environmentally and socially sound solutions for water quality, quantity, and equity issues. **NSF**
- **Cyber Energy Convergence:** Explores cyber resiliency enhancement opportunities for energy systems. **ONR**

5.2 Privacy Research and Development IWG

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.

Agencies: DHS, DOD, DOE, DOT/FHWA, NIH (Common Fund, ODSS, OSP), NIST & NSF

5.2.1 Strategic Priorities and Associated Key Programs/Activities

1. Understand Privacy Desires and Impacts.

- **Privacy Enhancing Technologies Evaluations**: Seeks to create joint efforts with DoD Special Operations Command and DHS Cybersecurity and Infrastructure Security Agency. **DHS & DOD**
- **Novel and Exceptional Technology and Research Advisory Committee:** Provides recommendations on research involving the use of, and developments in, emerging biotechnologies. **NIH**
- **Bioethics Grant Supplements:** Provides additional funds to recipients of NIH funds to conduct research on bioethical issues. **NIH/OSP**
- **NIH AI & Ethics working group:** Sponsors a trans-NIH AI and Ethics working group to coordinate and develop workshops, collaborations, and funding opportunities. **NIH/ODSS**

2. Develop System Design Methods that Incorporate Privacy Requirements and Controls.

- **Develop Guidelines and Special Publications:** Integrates privacy risk management into security publications for federal agencies and engagement with federal agencies. **NIST**
- **Privacy Framework:** Supports a resource repository for collaborating with public and private stakeholders, updating resources to align with NIST frameworks, and finalizing the privacy workforce taxonomy. **NIST**

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

- **Integrating Data for Analysis, Anonymization, and Sharing (iDASH) Genomic Privacy & Security Challenge:** Closes the technology gap by bringing advanced enabling technology to support human genomic research. **NIH**

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

- **Data Autonomy:** Supports innovation around user-driven privacy controls. **DHS**
- **iAGREE Consent Study:** Supports a multi-center patient consent study; meets with stakeholders to define needs; develops data sharing policies; and evaluates the platform's fit to those needs. **NIH**

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

- **PDaSP:** Enhances the ability to privately share and analyze data for a range of use cases and applications to solve real world problems**. DOT, FHWA, NIST & NSF**
- **National Covid Cohort Collaborative Privacy-Preserving Record Linkage:** Connects records using secure, pseudonymization processes in a dataset that refer to the same individual across different data sources while maintaining the individuals' privacy. **NIH**

- **Key Agency R&D Programs:** Develops privacy-enhancing cryptography project focusing on cryptographic tools that enable privacy goals in a myriad of computational and analytics applications. **NIST**

6. Develop solutions for recovery from privacy violations.

- **Database of Genotypes and Phenotype Policy & Response Plan:** Requires investigators using data from this system to notify the Data Access Committee within 24 hours of any data management incident and file a report within three business days outlining any actions taken to remediate the issue. **NIH**

6.0 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: DOC (NIST, NOAA, USPTO), DOD (DARPA), DOE/NNSA, DOE/SC, DOJ/NIJ, ED/IES, NASA, HHS (NIH, NIOSH), NSF & VA

6.1 Strategic Priorities & Associated Key Programs/Activities

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.

- **Graduate Research Fellowship Program:** Supports exceptional graduate students in full-time research-based STEM or STEM education programs. **DOE/NNSA, DOE/SC & NSF**
- **Computational Science Graduate Fellowship Internship Program:** Provides opportunities for doctoral students using HPC in science and engineering. **DOE/NNSA & DOE/SC**
- **Young Faculty Award:** Engages emerging researchers in junior roles to familiarize them with DOD needs and DARPA's process. **DARPA**
- **Law Enforcement Advancing Data & Science Scholars Program:** Develops research skills of mid-career law enforcement officers committed to integrating science into policies and practices. **NIJ**
- **National Initiative for Cybersecurity Education:** Energizes and promotes a robust network and an ecosystem of cybersecurity education, training, and workforce development. **NIST**
- **Professional Research Experience Program (PREP):** Provides valuable laboratory experience and financial assistance to researchers at various stages of their studies and careers. **NIST**
- **Summer High School Internship Program:** Provides interns the chance to engage in cutting-edge research at NIST and collaborate with staff scientists and engineers. **NIST**
- **Summer Undergraduate Research Fellowship (SURF) Program**: Provides interns with hands-on research experience in building and fire research technologies. **NIST**
- **CISE Graduate Fellowships:** Expands the diversity and number of domestic graduate students in computer fields. **NSF**

- **ExLENT:** Aims to provide professionals in any field with an experiential learning opportunity that builds the skills and competencies they need to pivot into careers in key technologies. **NSF**
- **NSF Entrepreneurial Fellowships:** Helps make entrepreneurship more accessible for people in less-developed innovation ecosystems, expanding diversity and increasing participation of women and others underrepresented in STEM. **NSF**
- **NSF Research Traineeship Program**: Provides graduate students with specialized training and funding assistance to join careers at the forefront of technology and innovation. **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:** Strengthens researcher-practitioner partnerships that foster R&D needed to bring computer science and computational thinking to all schools. **NSF**
- **Innovative Technology Experiences for Students and Teachers:** Supports foundational STEM education to promote equitable technology integration from pre-K through high school. **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.

- **Organizational Change for Gender Equity in STEM Academic Professions:** Supports systemic change projects to enhance gender equity and inclusion for STEM faculty. **NSF**
- **Eddie Bernice Johnson INCLUDES National Network Initiative:** Supports efforts to enhance leadership in STEM discovery and innovation, focused on accessibility and inclusivity. **NSF**
- **Improving Undergraduate STEM Education (IUSE):** Supports projects that enhance resources for two-year college students and faculty to fully engage in the STEM field. **NSF**
- **Research on Innovative Technologies for Enhanced Learning (RITEL):** Funds research in emerging technologies like AI, robotics, and immersive tech for teaching and learning. **NSF**

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

- **Predictive Science Academic Alliance Program:** Engages the U.S. academic community in advancing science-based modeling and simulation. **DOE/NNSA**
- **National Research Council (NRC) Postdoctoral Associateship Program:** Supports a nationwide postdoctoral program with the National Academies and NRC. **NIST**
- **PREP:** Provides valuable laboratory experience and financial assistance to researchers at various stages of their studies and careers. **NIST**

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

- **Research Experiences for Teachers in Engineering and Computer Science:** Provides research experiences for K-14 educators to build collaborations with academia and industry partners. **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. See also the AI R&D PCA.

- **Inclusive Intelligent Technologies for Education:** Explores how to leverage AI to support persistence, academic resilience, and collaboration within education technologies through the AI Institute jointly funded by NSF and Institute of Education Sciences (IES). **ED/IES**

- **IES Research Grants Programs:** Supports research through grant programs at the National Center for Education Research to enhance education quality, boost academic achievement, close achievement gaps, and expand postsecondary access. **ED/IES**
    - Advances the understanding and practices for teaching students at risk for disabilities through grant programs at the National Center for Special Education Research. **ED/IES**
- **National Institute for Exceptional Education:** Addresses the challenge of timely intervention by Speech and Language Pathologists amid staff shortages and resource constraints through the AI Institute jointly funded by the NSF and IES. **ED/IES**
- **PREP:** Provides valuable laboratory experience and financial assistance to researchers at various stages of their studies and careers. **NIST**
- **Computing in Undergraduate Education:** Supports rethinking scalable computing instruction to broaden participation among underrepresented and underserved groups. **NSF**
- **IUSE Education:** Supports projects to enhance STEM teaching and learning for undergraduates and transform institutions to adopt effective practices. **NSF**

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

- **CISE Research Experiences for Undergraduates:** Supports undergraduate research in computer science, information science, and cyberinfrastructure. **NSF**
- **Pathways to Enable Open-Source Ecosystem:** Enables the facilitation, creation and growth of open-source ecosystems for the creation of new technology solutions. **NSF**

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

- **Funding for Accelerated, Inclusive Research:** Aims to build research capacity and expertise at historically underrepresented institutions, including MSIs and Emerging Research Institutions. **DOE/SC**
- **Reaching a New Energy Sciences Workforce:** Aims to build foundations for Office of Science (SC) research at institutions historically underrepresented in the SC research portfolio. **DOE/SC**
- **NIST student opportunities:** Leverages student hiring programs like SURF, Pathways, and NRC post-docs to advance CNPS research. **NIST**
- **Smart and Connected Communities:** Supports use-inspired research that addresses communities' social, economic and environmental challenges. **NSF**

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

- **Usable Human-Centered Cybersecurity:** Conducts research in human factors, HCI, cognitive psychology and cybersecurity to guide policymakers and engineers on usability in cybersecurity. **NIST**
- **RITEL:** Supports early-stage research in AI, robotics, and immersive tech to address real-world educational needs. **NSF**

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

- **Advanced Technological Education:** Supports partnerships between two-year colleges, academic institutions, industry, and others to enhance technician education in science and engineering. **NSF**
- **Experiential Learning for Emerging and Novel Technologies:** Supports experiential learning to broaden access and interest in emerging tech careers for diverse backgrounds. **NSF**
- **Future of Semiconductors:** Supports collaborative research and education with industry on advanced semiconductor systems for energy efficiency and performance. **NSF**

7.0 Electronics for Networking and Information Technology (ENIT) PCA

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

Reporting Agencies: Army (ARL, ARO), DAF (AFRL), DHS, DOC (NIST, USPTO), DOD (DARPA, NSA, OUSD(R&D)), DOE/EERE, DOE/NNSA, DOE/SC, FBI, Navy (NRL, ONR), NASA, NSF, ODNI & State

7.1 Strategic Priorities & Associated Key Programs/Activities

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

- **Advance the development of quantum networking:** Advances efforts in devices, sensors and architectures. **DOE/SC, academic & industry partners**
- **Quantum Networking Research:** Advances in quantum networking and enabling effective interconnections among multiple quantum devices. **DOE/SC, academic & industry partners**
- **Convergence Accelerator (Track C: Quantum Technology):** Funding solutions for a diverse set of applications, including quantum sensors, interconnects, networks, workforce education, and more. **NSF**
- **Supplements for Access to Semiconductor Fabrication:** Supports the fabrication of research devices and systems through standard semiconductor fabrication facilities. **NSF**
- **Semiconductor Technology Pilot Program:** Supports the CHIPS Act by expediting patent examination for innovations that enhance semiconductor production, cut costs, and strengthen the supply chain. **USPTO**

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

- **Electronics Research Initiative:** Supports dedicated thrust area in hardware security, namely overcoming security threats across the entire hardware lifecycle. **DARPA**

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

- **Joint University Microelectronics Program 2.0:** Funds seven microelectronics centers at 39 universities with hundreds of graduate students and industry partnerships. **DARPA, academic & industry partners**

4. Facilitate technology transfer and commercialization.

- **Electronics Resurgence Initiative (ERI):** Focuses on developing disruptive dual-use electronics with an emphasis on manufacturing and commercialization. **AFRL, ARL, ARO, DARPA, DOE/SC, NIST, NRL, NSF, ONR & OUSD(R&E)**
- **Industry-University Cooperative Research Centers:** Generates breakthrough research through close collaboration among industry, academia, and government. **NSF**
- **NSF Innovation Corps:** Offers an immersive, entrepreneurial training program that facilitates the transformation of inventions to impacts. **NSF**
- **Small Business Innovation Research and Small Business Technology Transfer Program:** Transforms scientific discoveries into commercially viable products and services. **NSF**

8.0 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, algorithms, software, and data analytics that enable extreme data- and computation-intensive workloads while addressing challenges such as system performance, reliability, trust, transparency, energy efficiency, and other methods.

8.1 High End Computing (HEC) IWG

The HEC IWG coordinates federal R&D to enhance U.S. advanced computing capabilities and explore fundamentally new approaches to computing, focused on bolstering U.S. dominance in high-capability computing (HCC). Advancements in HCC are essential drivers of technological progress, scientific discovery, and innovation across various sectors and endeavors vital to the nation such as exascale computing and other advanced data center and edge computing technologies to meet needs for modeling and simulation, data storage and analysis, and AI training and inference. The rapidly evolving technology landscape and user needs along with energy efficiency needs drive transformational and incremental advancements in all areas of HCC to meet capability goals and productivity requirements needed to enhance scientific insight, accelerate discoveries, and prepare for the next computing evolution.

Agencies: Army, DOC/NIST, DOD/NSA, DOE/NNSA, DOE/SC, HHS/NIH, NASA, Navy, NIH/NCI & NSF

8.1.1 Strategic Priorities & Associated Key Programs/Activities

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

- **Emerging architecture testbed:** Continues exploration of emerging architecture via testbeds. **Army**
- **Exascale software technology:** Explores how DOD can benefit from DOE's exascale software technology, optimized for exascale. **Army**
- **Next-Generation Software Technologies:** Develops application and software technology on exascale hardware and HCC resources. **DOE/SC**
- **Post-Exascale Computing Initiative investment portfolio:** Supports component technology investigation of advanced memory technologies and next generation of networking. **DOE/SC**
- **Application Software Modernization:** Develops domain-specific middleware layer for Earth system models and modernizes applications and port to a new architecture. **NASA**

- **Computing testbeds:** Invests in new computing architectures and commercial-cloud HPC capabilities. **NIST**

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

- **R&D of technologies for the advancement of quantum computing:**
  - **Joint Center for Quantum Information and Computer Science:** Supports research and education in quantum computer science and information theory. **NIST, NSA & academic**
  - **Quantum Computing:** Focused on fault-tolerant algorithms, and control systems for NNSA mission needs. **DOE/NNSA**
- **R&D to drive the evolution of neuromorphic computing:**
  - Explores neuromorphic computing via NNSA trilabs sharing testbeds. **DOE/NNSA**
  - Develops superconducting and optoelectronic devices and algorithms for spiking neuromorphic processors. **NIST**
  - Explores metrology for memristive devices, stochastic tunnel junctions, and circuits that use them. **NIST**
- **Quantum network testbed:** Develops an internal quantum network testbed. **NIST**
- **Quantum research:** Improves quantum characterization and explores quantum error correction, theoretical limitations of quantum circuits, and limitations of quantum computers. **NIST**
- **Foundations of Emerging Technologies:** Supports unconventional computing approaches whose potential is not yet fully realized. **NSF**

3. Research and develop new approaches and techniques aimed at improving the programmability, portability, reliability, and usability of high-capability computing, broadening the impact and applicability of the HCC.

- **Post-exascale effort:** Supports hardware and software research, development, and demonstration. **DOE/NNSA, various other federal agencies & international partners**
- **Frontier Projects**: Pioneers new techniques for projects that require largest HPC resources. **Army**
- **Productivity Enhancement and Training:** Provides expertise to adopt new programming approaches that take advantage of state-of-the-art hardware and software. **Army**
- **Software Institutes:** Expedites development of the next generation of HPC software. **Army**
- **Software Stack for Extreme HPC Heterogeneity:** Supports the basic R&D advanced programming models, programming environments, AI integration, and other areas. **DOE/SC**
- **Human-centered computing (HCC) Assimilation:** Develops computing infrastructure to assimilate HEC into agency mission directorate to support missions such as wildfire efforts. **NASA**
- **Helping to End Addiction Long-Term Program:** Develops an integrated computational platform to provide the chemical intelligence to support automated, high throughput synthesis of new opioid related drugs to help combat drug addiction. **NIH**
- **Science and Technology Research Infrastructure for Discovery, Experimentation, and Sustainability (STRIDES):** Develops and tests new ways to make large data sets and associated computational tools available to wider audiences of biomedical researchers and clinicians. **NIH**
- **Cluster Scale Abstraction:** Develops cluster scale asynchronous run time system. **NIST**
- **HedgeHog:** Supports research to identify software abstraction for parallelism targeting high-end heterogeneous compute nodes. **NIST**

- **Principles and Practices of Scalable Systems**: Supports research to increase scalability in large-scale parallel computer systems. **NSF**

4. Develop, foster, and broaden a diverse and inclusive HEC workforce for computing R&D to bolster technological competitiveness.

- **Engages the STEM community to broaden HCC impact and strengthen the cyberinfrastructure ecosystem:**
  - **Community engagement:** Supports Hackathons, cluster competitions, tutorials, and workshops. **NASA**
  - **Open Data Science Gateway for the DS-I Africa Consortium:** Creates and supports a robust pan-continental network of data scientists and technologists. **NIH**
  - **CISE Educational and Workforce Program:** Promotes leadership and efforts to engage the community in infusing computational thinking into education levels across disciplines. **NSF**
  - **Strengthening the Cyberinfrastructure Professionals Ecosystem:** Supports the integration of cyberinfrastructure professionals' services into research. **NSF**
  - **Training-based Workforce Development for Advanced CI:** Supports training and education to address the emerging needs and bottlenecks in S&E research workforce development. **NSF**
- **Research opportunities that advance the knowledge and use of advanced computing:**
  - **Better Scientific Software Fellowship Program:** Funds leaders and advocates of high-quality scientific software to improve productivity and sustainability. **DOE/NNSA, DOE/SC & NSF**
  - **DOE Computational Science Graduate Fellowship:** Supports students pursuing doctoral degrees in fields that use HPC to solve complex S&E problems. **DOE/NNSA & DOE/SC**
  - **Faculty Immersion Experience:** Provides research experiences for university faculty to strengthen collaboration and research capabilities and encourages broader participation. **Army**
  - **High Performance Computing Internship Program:** Pairs undergraduate or graduate STEM students for 10-week on-site research experiences with DOD mentors. **Army**
  - **Predictive Science Academic Alliance Program:** Provides students the experience for weapons code development and engages academia to establish various science programs. **DOE/NNSA**
  - **RENEW Initiative:** Provides hands-on experiences to participants, forming a future pool of talented young scientists, engineers, and technicians for DOE/SC research activities. **DOE/SC**
  - **Learning opportunities:** Works with MSIs to provide learning opportunities in HEC technologies through internships, curriculum development and resource sharing. **NASA**
  - **National Research Council Postdoctoral Associateship Program:** Provides postdoctoral scientists and engineers the opportunity to pursue research on problems that are compatible with the interests of the sponsoring laboratories. **NIST**
  - **Professional Research Experience Program:** Provides laboratory experience and financial assistance to undergraduates, graduate students, postdocs, and faculty. **NIST**
  - **Summer High School Internship Program:** Provides students a chance to participate in cutting-edge research at NIST and work with their staff scientists and engineers. **NIST**
  - **Summer Undergraduate Research Fellowship Program:** Provides hands-on research experience. **NIST**
  - **Frontera Computational Science Fellowships:** Provides a year-long opportunity for graduate students to compute on the most powerful academic supercomputer in the world. **NSF**

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

HCIA provides high-capability computing systems, application software, and infrastructure; this includes computing, software and services, communications, storage, and data infrastructure, coordination services, and other necessary resources for the effective use of high-capability computing

9.1 High End Computing (HEC) IWG

In addition to coordinating EHCS R&D, the HEC IWG coordinates federal activities to provide high-capability computing (HCC) systems and infrastructure (including expertise necessary to use the HCC systems effectively) and develop algorithms and applications to support agency missions and accelerate scientific discoveries and technological innovations in areas such as materials discovery and design, energy research and exploration, Earth and space science, early-stage research of advanced technologies, understanding of human body for detection and treatment of diseases, advanced weapons design, forecasting and hazard response planning, climate science, and many other Science and Engineering (S&E) applications. HCIA provides capabilities that are vital in shaping the future of research, industry, and society and is a key enabler in addressing some of the most pressing issues the Nation faces today.

Agencies: Army, DOC/NIST, DOD, DOE/NNSA, DOE/SC, DOI/USGS, NASA, NIH/NCI & NSF

9.1.1 Strategic Priorities & Associated Key Programs/Activities

1. Acquire, operate, and provide leadership-class and production-quality HCC systems those required to meet critical national needs, including AI, and support research and education across all S&E areas.

- **Dedicated High Performance Computing Project Investments:** Awards small HEC systems based on needs outside the DoD Supercomputing Resource Centers. **Army**
- **DOD Supercomputing Resource Centers:** Provides computing capacity to DOD at the unclassified, collateral secret, and above-secret levels. **Army**
- **HPCMP Ecosystem:** Provides shared large-scale HPC supercomputers, early access to emerging architectures, and cloud capabilities. **Army**
- **Advanced Scientific Computing Research Leadership Computing Challenge program:** Supports program to enable high-risk, high-payoff simulations in areas related to the DOE mission. **DOE/SC**
- **High Performance Data Facility:** Supports a new scientific user facility specializing in advanced infrastructure for data-intensive science. **DOE/SC**
- **HPC and Network Facilities:** Supports leadership HCC at Argonne (Aurora and Polaris systems), Oak Ridge (Frontier system), and National Energy Research Scientific Computing Center (Perlmutter system) for world-class research. **DOE/SC**
- **Innovative and Novel Computational Impact on Theory and Experiment program:** Continues program pushing the computational boundaries accelerate scientific discovery. **DOE/SC**
- **HEC Capability Project:** Provides computing capacity to Ames Research Center, supports all NASA computational projects, and expands computing using eco-friendly modular facilities. **NASA**
- **Scientific Computing:** Provides computing capacity to the Center for Climate Simulation and expands computing resources with hybrid on-premise and commercial clouds. **NASA**
- **Molecular Transducers of Physical Activity Consortiums:** Provides computational infrastructure and database for storing, integrating, and analyzing clinical data. **NIH**

- **HCC capabilities expansion:** Expands HCC capabilities for research via a partnership with other leading-edge centers in the US and purchase of a medium-scale cluster for internal research. **NIST**
- **Advanced Computing Systems & Services: Adapting to the Rapid Evolution of Science and Engineering Research:** Manages a range of HCC resources, including DeltaAI at the National Center for Supercomputing Applications and Stampede3 at the Texas Advanced Computing Center (TACC). **NSF**
- **Leadership-Class Computing Facility (LCCF) program:** Provides large-scale computational and data analytics for the NSF research community, including the planned LCCF at TACC. **NSF**
- **Major Research Instrumentation:** Supports acquiring HCC resources at academic campuses to increase access to shared scientific and engineering instruments for research and training. **NSF**
- **Mid-scale Research Infrastructure:** Supports the design and implementation of research infrastructure, including equipment, cyberinfrastructure, large-scale datasets, and personnel. **NSF**

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

- **Computational Research and Engineering Acquisition Tools and Environments program:** Develops and deploys multi-physics software for the DOD acquisition engineering community in air, ground, and naval vehicles, as well as RF antennas. **Army**
- **DOD HPCMP Software Applications:** Adapts widely used applications and algorithms to address DOD research, development, test and evaluation and acquisition engineering requirements. **Army**
- **Computational Modeling and Analysis program:** Modernizes global model and ports major aeronautic codes through the application of domain-specific languages. **NASA**
- **Helping End Addiction Long-term:** Uses advanced computational approaches to link addiction-related behaviors to underlying neural mechanisms. **NIH**
- **National Institute of Mental Health Data Archive:** Supports large-scale multisite and multimodal studies and data type-specific processing, coordination, analysis, and computational analyses. **NIH**
- **Precision Nutrition:** Integrates the domains of precision nutrition, AI (including machine learning), systems biology, systems science, big data, and computational analytics. **NIH**
- **Cyberinfrastructure for Sustained Scientific Innovation:** Develops software and data services for all aspects of cyberinfrastructure with new project class on transition to sustainability. **NSF**

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

- **Cloud interface:** Develops HPC in the cloud interface. **Army**
- **HPC Portal, Open OnDemand pilot:** Tests and provides web-based HPC access. **Army**
- **Integrated Research Infrastructure:** Addresses the challenges of near real-time computing to support the growing scientific data from upgrades at SC's Scientific User Facilities. **DOE/SC**
- **Computing Service project:** Enhances infrastructure to enable ML/AI research and provide scientific data for open science through innovative use of cloud and on-prem resources. **NASA**
- **Common Fund Data Ecosystem:** Supports a trans-CF effort to enable researchers to query across multiple disparate data sets. **NIH**
- **Campus CI Program:** Provides coordinated campus-level networking and CI improvements, innovation, integration, and engineering for science applications and research projects. **NSF**
- **Partnership to Advance Throughput Computing:** Provides distributed high throughput computing services, combining Open Science Grid with Center for High Throughput Computing. **NSF**

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

- **Energy Sciences Network (ESnet):** Supports and maintains ESnet, a science network optimized for the requirements of large-scale science. **DOE/SC**
- **Training:** Provides extensive training programs at leadership computing facilities for effective use of computing and technology. **DOE/SC**
- **3D capabilities:** Enhances 3D immersive capabilities, in collaboration with industry, for use in 3D immersive environments. **NIST**
- **Cyberinfrastructure Technology Acceleration Pathway:** Supports a pathway service that translates research CI software innovations to production-quality services. **NSF**
- **Computational Center for the Earth Sciences:** Establishes a center to advance Earth sciences through resources, expertise, and cutting-edge computational methods. **USGS**

10.0 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.

10.1 Intelligent Robotics and Autonomous Systems IWG

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.

Agencies: Army (AI2C, ARL, C5ISR, DEVCOM, ERDC, GVSC), DAF (AFOSR, AFRL, AFWERX, AFTC, Space Force), DHS, DOD (CDAO, NRO, OUSD(R&E), SOCOM), DOE (NRC), DOI, DOT/FAA, HHS (NIH, NIOSH), Marines, NASA (JPL), Navy, NIST, NSF, ONR, OSHA & USDA-NIFA

10.1.1 Strategic Priorities & Associated Key Programs/Activities

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

- **Combat Vehicle Robotics:** Improves human-autonomy teaming and enables scalable multi-domain autonomy to lower cognitive load for operators and optimizing effectiveness. **ARL, C5ISR, ERDC & GVSC**
- **Human Autonomy Teaming:** Develops technologies to rapidly configure to execute missions in complex environments and adapt to adversaries and changing machines. **ARL, C5ISR & GVSC**
- **Ground Enabling University:** Delivers robust autonomous capabilities for air-ground teaming and human-robotic artificial intelligence interactions. **ARL & GVSC**
- **Foundational Research in Robotics:** Supports research on robotic systems that exhibit significant levels of both computational capability and physical complexity. **NSF & USDA-NIFA**
- **Project Fast Open X-Platform:** Establishes an open software enclave to install apps directly onto aircraft without altering proprietary source code. **AFTC**
- **Computational Cognition and Machine Intelligence:** Enables intelligent machine behavior, particularly in support of mixed-initiative (i.e., human-machine teaming) systems. **DAF**

- **Trust and Influence Program:** Elucidates the social and cognitive principles in the establishment, maintenance, and repair of trust between humans and technologies. **DAF**
- **Robotics for Engineering Operations:** Improves autonomy and robotics platforms for Army engineer operations, with focus on beyond line-of-sight operations and efficient human machine teaming. **ERDC**
- **Aeronautics University Leadership Initiative on Effective Human-Robot Teaming to Advance Aviation Manufacturing:** Studies how human-robot teaming can improve the efficiency of aviation manufacturing, while enhancing ergonomics and safety. **NASA**
- **NASA Space Technology Graduate Research Opportunities (NSTGRO):** Supports foundational research in Human-Robot Interaction. **NASA**
- **Multi-Body 3D-2D Registration for Robot-Assisted Joint Reduction:** Enables image-guided, robot-assisted reduction of joint dislocation in orthopedic surgery. **NIH**
- **Overcoming the Intraoperative Data Desert:** Develops biophotonics, advanced Sensing, and control for Automated Surgery. **NIH**
- **Vitreoretinal Surgery via Robotic Microsurgical System with Image:** Develops guidance, force feedback, virtual fixture, and augmented reality. **NIH**
- **Intervention Research to Improve Safety Around Robots and Research into Human-Robot Collaboration Programs:** Develops and evaluates engineering controls and workplace interventions for safe and effective human-robot teaming. **NIOSH**
- **Research Evaluating Risk Factors for Robot-Related Injuries:** Studies of contributing factors, tasks and environmental characteristics biomechanics, anthropometry, and cognition. **NIOSH**
- **Future of Work at the Human-Technology Frontier:** Addresses the challenges and opportunities in jobs and work, as enabled, intensified, or created by human-technology partnership. **NSF**
- **Human-Centered Computing:** Supports research in human-computer interaction, including human-robot interactions. **NSF**
- **Mind, Machine, & Motor Nexus:** Integrates understanding and design of physical interactions between humans and intelligent machines. **NSF**

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.

- **Multiple Programs utilizing XQ-58 Valkyrie as a test bed including - Autonomous Air Combat Operations, Air Combat Evolution:** Creates active, responsive approaches to stimulate autonomous responses real-time in airborne environments. **AFRL, AFTC, DARPA, Marines & Navy**
- **Automated Target Recognition – Mobile Cooperative Autonomous Sensors:** Develops AI and ML algorithms to autonomously navigate and collaborate through shared perception to find, identify, geo-locate and track targets. **AI2C, C5ISR & GVSC**
- **Artificial Intelligence & Machine Learning Tech:** Enables autonomous maneuver of combat vehicles that unburden the Soldier in highly contested environments. **ARL & GVSC**
- **Modeling and Simulation for Manned-Unmanned Team:** Develops tools for virtual prototyping, and testing and evaluation of autonomous systems, decreasing the development time and amount of physical testing needed. **Army**
- **Game Changing Development:** Develops Mid-Technology Readiness Levels (TRL) projects developing autonomy technologies for future space missions, including multi-robot teaming (space & surface). **NASA**
- **NASA Innovative Advanced Concepts Extramural Awards:** Develops new space robots to explore extreme environments. **NASA**

- **Space Technology Research Grants (STRG) Coordinated Multi-Robots for Planetary Exploration:** Develops algorithms, methods, and prototypes that enable forceful environment/object interaction with robot teams. **NASA**
- **Bridging Clinical Trial and Real-World Data via ML to Advance Rheumatoid Arthritis Treatment Strategies:** Develops test methods using semi-supervised ML methods to impute Rheumatoid Arthritis Comparison of Active Therapies clinical endpoints. **NIH**
- **Developing an Objective and Quantifiable Measure of Itch Using Artificial Intelligence and Radio Signals:** Provides an objective, sensitive, and reliable metric for measuring both itch and its impact on sleep. **NIH**
- **PostureCheck:** Enhances performance of the BURT® upper-extremity stroke therapy device. **NIH**
- **Robot-related Workplace Fatalities and Injuries Surveillance:** Improves the utilization of current surveillance tools, which do not effectively capture robot-related workplace injuries. **NIOSH**
- **Safety Standards, Certifications, and Regulations:** Evaluates the effectiveness of existing safety standards, certifications, and regulations and the development of new consensus standards where needed. **NIOSH**
- **Dynamics, Control and Systems Diagnostics:** Supports fundamental research in dynamics, including topics of modeling, analysis, diagnostics, and control. **NSF**
- **Robust Intelligence:** Develops systems that can sense, learn, reason, communicate, and act in the world. **NSF**
- **Engineering for Precision Crop and Water Management:** Provides precision crop and orchard management, technologies for targeted application of crop protection materials, and improve efficiency of irrigation and nutrient use in agricultural systems. **USDA-NIFA**

3. Increase investment in innovative R&D and the implementation of intelligent autonomous robots and enabling technologies.

- **Autonomous Mobility:** Develops data pipeline for curating, hosting, and sharing ground vehicle data across the army and integrating with data tools for use in AI/ML capability. **AI2C, ARL, GVSC & Marines**
- **Emerging Frontiers in Research and Innovation - Brain-Inspired Dynamics for Engineering Energy-Efficient Circuits and Artificial Intelligence:** Supports interdisciplinary research to create a new engineering science of BRAIN-inspired engineered learning systems. **AFOSR, NASA & NSF**
- **Sensors for Autonomous Operations and Survivability:** Develops next generation of electro-optical/infrared sensors to extend range and enable advanced threat detection. **ARL & C5ISR**
- **Smart Health and Biomedical Research in the Era of Artificial Intelligence and Advanced Data Science:** Accelerates the development and integration of innovative computer science and engineering approaches that would support the transformation of health and medicine. **NIH & NSF**
- **Dynamical Systems and Control Theory:** Develops innovative synergistic strategies for the design and analysis of controlled systems. **Army**
- **NASA Innovative Advanced Concepts:** Advances mobile manipulation platforms that leverage lightweight extendable booms to achieve large reach with a small footprint. **NASA**
- **NASA STRG:** Develops real-time legged manipulator planning; ice anchor grippers; hybrid aerobot-vine robots; robot navigation and multi-agent tasking for image-based search. **NASA**
- **Improving the Health Status of Dysvascular Amputees by Deploying Digital Prosthetic Interface Technology in Combination with Exercise Intervention:** Deploys a computationally derived transtibial prosthetic interface technology to promote health exercise intervention. **NIH**

- **Funding of Extramural Research on Robotics, Automation, and Enabling Technologies:** Advances automation, robotics, and intelligent systems in the mining industry and for evacuation and rescue from underground mine emergencies. **NIOSH**
- **Convergence Accelerator (Track H: Enhancing Opportunities for Persons with Disabilities):** Bringing together a wide range of disciplines/sectors to develop new technologies and tools to enhance quality of life and employment access and opportunities for persons with disabilities. **NSF**
- **Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR):** Supports startups and small businesses transform their ideas into marketable products and services, with focus on high-risk, high-impact technologies, including robotics. **USDA-NIFA**

4. Advance the role of robotics in improving the resilience of critical infrastructure: (a) to respond to failures, incomplete or corrupted information and unknown environments; (b) to assist in national response to critical and emergent events including national disasters and emergencies; and (c) to help with the physical acquisition, understanding, analyzing and processing digital information in more robust and efficient ways.

- **Cyber-Physical Systems:** Supports research in closed loop and human-in-the-loop systems that focuses much of its work on critical infrastructure. **DHS, DOT, NIH, NSF & USDA-NIFA**
- **Multimodal Active Perception System:** Develops interoperability through a common operating picture & User Interface for collected data by U.S. & Singapore ground & air uncrewed systems. **ARL & OUSD(R&E)**
- **Smart and Connected Communities/Civic Innovation Challenge (CIVIC):** Supports integrative research that addresses fundamental technological & social science dimensions. **NSF & USDA-NIFA**
- **NASA NSTGRO:** Supports foundational research in robot system science; including control, task/motion planning, & multi-robot systems. **NASA**
- **Space Technology Graduate Research Smart Deep Space Habitats:** Develops technologies to enable resilient space habitats by making pervasive use of autonomy and robotics. **NASA**
- **Research on Adaptable Robots for use in Dynamic Situations:** Supports the evaluation of adaptability of robots in dynamically changing situations. **NIOSH**
- **Research on Human-Robot Collaboration and Trust:** Supports the exploration of human responses in collaborative workspaces. **NIOSH**
- **Rapid Response Research:** Funds proposals that have a severe urgency with regard to availability of, or access to data, facilities or specialized equipment, including quick-response research. **NSF**
- **Rapid Response to Extreme Weather Events Across Food and Agricultural Systems:** Supports research to alleviate the impacts of disasters across the food and agricultural system. **USDA-NIFA**

5. Develop and promote test and evaluation in standards to address responsible, ethical, and safe use of robotics, and increase broader and equitable participation in robotics.

- **Autonomy Data and AI Experimentation Proving Ground:** Evaluates AI systems and accelerates implementation of AI enabled autonomy. **AFRL, AFTC, AFWERX, CDAO & SOCOM**
- **NASA SBIR/STTR:** Develops robot sensors, non-prehensile manipulation, & robot software frameworks. **NASA**
- **Bioethical, Legal, and Anthropological Study of Technologies:** Examines the data practices, data privacy, data access, and data justice issues in healthcare: robotics, bionics, and bioprinting. **NIH**
- **Research on Bioethical Issues Related to Bionic and Robotic Device Development and Translation:** Supports research on the ethical questions associated with all stages of the design, testing, and/or implementation of bionic and robotic devices. **NIH**

- **Technology Development to Reduce Health Disparities:** Develops and translates medical technologies aimed at reducing disparities in healthcare access and health outcomes. **NIH**
- **Understanding and Mitigating Health Disparities experienced by People with Disabilities caused by Ableism:** Supports research on the underlying mechanisms by which ableism adversely influences the health of persons with disabilities. **NIH**
- **Focus on Robotics Education:** Funds academic robotics research through extramural research program for the evaluation of the impact of education and training on robotics. **NIOSH**
- **Focus on the Effects of New Technologies on Health Equity:** Supports and evaluates training considering differences in race, ethnicity, age, sex, and other equity factors. **NIOSH**
- **Focus on Worker Displacement:** Assesses whether advantages of robotic safety replacements outweigh the toll of displacement for workers who cannot be retrained. **NIOSH**
- **Broadening Participation in Computing:** Supports increases in U.S. citizens, permanent residents and underrepresented groups receiving post-secondary degrees in the computing disciplines. **NSF**
- **ReDDDoT:** Invites proposals from multidisciplinary/multi-sector teams that examine & demonstrate the principles/methodologies/implementations & impacts associated with design/development, and deployment of technologies in practice. **NSF**
- **Research Traineeship Program:** Explores ways for graduate students in research-based degree programs to develop the skills, knowledge, and competencies needed to pursue a range of STEM careers. **NSF**
- **AFRI Education & Community Development Programs:** Focuses on the next generation of research, education, and extension professionals in the food and agricultural sciences. **USDA-NIFA**

11.0 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.

11.1 Big Data (BD) IWG

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

Agencies: DARPA, DHS, DOC (NIST, NOAA), DOD, DOE/NNSA, DOE/SC, DOI/USGS, HHS/NIH, NASA, NRO & NSF

11.1.1 Strategic Priorities & Associated Key Programs/Activities

1. Support the foundational research, innovative tools, and methodologies that maximize the use of large-scale data resources to solve priority challenges in areas such as U.S. security, economy, health, and climate change.

- **Resilient Supply-and-Demand Networks:** Develops analytical tools to expose and mitigate surprise in supply and demand networks. **DARPA**
- **Biopreparedness Research Virtual Environment:** Supports national biopreparedness and response, focusing on tool development and issues in data, AI, HPC, and facilities. **DOE/SC**
- **Foundational Research in Data Visualization:** Leverages advanced hardware and develops new techniques for visualizing extreme scale, complex, and multi-modal data. **DOE/SC**

- **Foundational Research in Management and Storage of Scientific Data:** Exploits new memory and storage technologies with a focus on supporting applications with streaming data, ML, and metadata. **DOE/SC**
- **Earth Science Division:** Supports environmental justice communities by expanding awareness, accessibility, and use of Earth science data. **NASA**
- **Solar Dynamics Observatory (SDO):** Translates SDO data into a fully resolved helio foundation model and improves input into the Sun-Earth climate connection. **NASA**
- **BioData Catalyst:** Provides a cloud-based ecosystem that offers data, analytic tools, applications, and workflows in secure workspaces. **NIH**
- **NIH Integrated Data Analysis Platform Expansion:** Supports cloud-based and collaborate data aggregation and analysis platforms, including addressing data management and analysis needs. **NIH**
- **Sequence Read Archive:** Supports one of the largest publicly available repositories of high throughput sequencing data. **NIH**
- **CISE Core Program:** Provides support for new and innovative research on data science techniques. **NSF**
- **Collaborations in Artificial Intelligence and Geosciences:** Support the development and adoption of innovative AI methods to increase scientific understanding of the Earth system. **NSF**
- **Computational and Data Enabled Science and Engineering Program:** Supports major scientific and engineering breakthroughs through new computational and data-analysis methods. **NSF**
- **Principles and Practices of Scalable Systems:** Supports basic research on the scalability and toolchains and fosters the development of principles leading to reproducible artifacts. **NSF**

2. Supports ethics, security, and privacy in innovation by advancing the reliability, accuracy, performance, generalizability, and transparency of data-driven discovery and decision making.

- **Foundational Research in Uncertainty Quantification:** Supports research to understand the uncertainty arising from complex or sparse data and the effects on decision making. **DOE/SC**
- **Fundamental Research into Explainable AI:** Conducts research on methods to extract scientific insight from ML models. **DOE/SC**
- **Fundamental Research into Scalable AI:** Conducts research to enable ML to run distributed HPC systems with large, multidimensional data. **DOE/SC**
- **Fundamental Research into Scientific Machine Learning for Complex Systems:** Researches domain aware, interpretable, and robust ML to enhance capabilities for handling large data. **DOE/SC**
- **Guidelines Evaluation:** Evaluates the implementation of guidelines for the ethical use of AI in NASA scientific investigations. **NASA**
- **Transition to Open Science Program:** Continues the application of open science (OS), including research of transparency, reproducibility, and access to resources. **NASA**
- **Bridge2AI:** Develops datasets, tools, software, and standards to accelerate the creation of AI/ML-ready datasets. **NIH**
- **Rapid Acceleration of Diagnostics (RADx) – Data for Indigenous Implementations, Interventions, and Innovations (D4I):** Implements the RADx D4I, a data repository with sovereignty-based governance for researchers. **NIH**
- **Cybersecurity Innovation for Cyberinfrastructure:** Supports research for scientific CI, including security, integrity, provenance, and availability of end-to-end scientific workflows and data. **NSF**

- **Secure and Trustworthy Cyberspace Program:** Supports research on the topics of data science, ML, and AI in service of data security and privacy. **NSF**

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

- **Findable, Accessibility, Interoperability, and Reusability (FAIR) Data and Models for Science:** Supports FAIR Data & Models for Science, including benchmarking and developing tools for FAIR data. **DOE/SC**
- **NASA Science Mission Directorate (SMD) Data and Knowledge:** Implements, refines, validates, & maintains a Large Language Model to improve discoverability of SMD data & knowledge. **NASA**
- **Visualization, Exploration, and Data Analysis:** Develops an open platform for geospatial data in the cloud. **NASA**
- **National Cancer Institute's Cancer Research Data Commons:** Connects datasets with analytics tools to allow users to share, integrate, analyze, and visualize cancer research. **NIH**
- **NIH Cloud Platform Interoperability Administrative Coordinating Center:** Supports projects driven by scientific use cases, leveraging datasets from multiple NIH cloud repositories. **NIH**
- **Advanced CI Coordination Ecosystem:** Provides a wide range of NSF-supported advanced shared resources, to create an agile, integrated, robust, trustworthy, and sustainable CI. **NSF**
- **Campus CI:** Addresses science-driven needs in data storage resources and shared resource needs at the regional level. **NSF**
- **Convergence Accelerator:** Accelerates use-inspired, convergence research in areas of national importance via partnerships between academic and non-academic stakeholders. **NSF**
- **CI for Sustained Scientific Innovation:** Supports interoperability of data and provides an opportunity to advance common approaches to sustain and innovate research CI. **NSF**
- **Findable Accessible Interoperable Reusable Open Science (FAIROS):** Supports research, education, and CI development activities that advance FAIR data principles and OS practices. **NSF**
- **Geosciences Open Science Ecosystem:** Leverages CI ecosystem and OS activities across NSF, focusing on broadening access and advancing open science principles in the geosciences. **NSF**
- **Research Infrastructure in the Social and Behavioral Sciences:** Supports projects that create computational tools and data to facilitate basic research in the social and behavioral sciences. **NSF**

4. Enables time-sensitive data-driven decision making through scalable high-performance analytics ecosystems and large-scale data resources.

- **AI Institutes:** Supports the development of new AI Institutes, including time-sensitive data-driven components in various institutes. **DOD, NIST & NSF**
- **Co-Design of Data Analysis and Reuse at Scientific User Facilities:** Supports research partnerships to enable broad engagement with scientific data, and new paradigms of experimental science through data management. **DOE/SC**
- **Data Reduction:** Supports research to maximize scientific information from data generated at large-scale facilities and unify a wide variety of reduction techniques. **DOE/SC**
- **Distributed, Resilient Systems:** Develops approaches to create distributed resilient systems for science, including managing computation and data in scalable and fault-tolerant manner. **DOE/SC**
- **Integrated Research Infrastructure Initiative:** Addresses the challenges of modern scientific discovery, including management and exchange of massive amounts of data generated. **DOE/SC**
- **AIST Program:** Explores the use of Earth Science digital twins to support research and Earth Science action decision-making. **NASA**

- **Remote Sensing Data:** Supports remote sensing data used to assess plant health and expand the ongoing experiments in the application of NASA space-based remote sensing data. **NASA**
- **National COVID Cohort Collaborative:** Supports centralized, secure national data resources with analytic capabilities exploring privacy-preserving linkage for deduplication and data sources. **NIH**
- **Science and Technology Research Infrastructure for Discovery, Experimentation, and Sustainability:** Develops and tests new ways to make large data sets and computational tools available and accessible by wider audiences of biomedical researchers and clinicians. **NIH**

5. Builds a diverse multigeneration workforce necessary to develop, support, and use all aspects of big data.

- **Computational Sciences Graduate Fellowship:** Provides benefits and opportunities to students pursuing doctoral degrees, focusing on topics in computer science and applied math for HPC. **DOE/NNSA & DOE/SC**
- **Computing Research Association:** Supports career development and outreach workshops for computer science. **DOE/SC**
- **FAIR:** Builds research capacity, infrastructure, and expertise at minority-serving institutes. **DOE/SC**
- **Office of Science Early Career Research Program:** Supports exceptional researchers during early career years. **DOE/SC**
- **Reaching a New Energy Sciences Workforce:** Provides training opportunities for students and academic institutions not currently well represented in the US S&T. **DOE/SC**
- **Data Science Equity, Access, and Priority in Research & Education Program:** Supports minority university research and education project focusing on data science and capacity building. **NASA**
- **Internships and Reskilling:** Recruits interns to work on existing missions and reskills the existing workforce to use advanced AI tools. **NASA**
- **Accelerating Medicines Partnership Autoimmune and Immune-Mediated Diseases program:** Supports the Leadership Scholars Program that develops scholars who specialize in women's health studies in autoimmune and immune-mediated diseases. **NIH**
- **Data and Technology Advancement National Service Scholar Program:** Brings experienced data and computer scientists and engineers to tackle challenging biomedical data problems. **NIH**
- **The Artificial Intelligence and Machine Learning Consortium to Advance Health Equity and Research Diversity:** Establishes partnerships to increase the participation and representation of researchers and communities currently underrepresented in the development of AI/ML models. **NIH**
- **Computer and Information Science and Engineering Minority-Serving Institutions Research Expansion Program (CISE-MSI Program):** Supports broadening the participation and develops research capacity by increasing the number of CISE-funded research projects from MSIs. **NSF**
- **CyberTraining:** Supports training-based workforce development for advanced cyberinfrastructure to prepare, nurture, and grow the national scientific research workforce. **NSF**
- **NSF Research Traineeship:** Encourages the development and implementation of transformative models for STEM graduate education training, including a focus on data. **NSF**
- **Strengthening the CI Professionals Ecosystem:** Ensures fair and equitable access to resources, services, and expertise by strengthening how CI Professionals function in the research ecosystem. **NSF**

6. Transitions R&D to community practice through innovative partnerships.

- **SciDAC Institutes:** Assists SciDAC and DOE domain scientists and engineers to solve computer science, data, and AI challenges through the use of DOE supercomputers. **DOE/SC**

- **Software Sustainability:** Supports and develops the software ecosystem needed for computational science and provides shared software packages. **DOE/SC**
- **Remote Sensing Data Availability:** Increases the availability of commercial remote sensing data to Earth science research. **NASA**
- ***All of Us* Research Program:** Gathers health data and increases access to data and tools for researchers and returns value to participants through health-related information. **NIH**
- **Human Networks and Data Science:** Supports research that enhances the understanding of human behavior by leveraging data and network science research across a broad range of topics. **NSF**
- **Pathways to Enable Open-Source Ecosystem program:** Utilizes the power of open-source development to create new technology solutions to problems of national and societal importance. **NSF**
- **Space Act Agreements (SAA):** Utilizes SAA to create non-reimbursable agreements with computing and AI companies to pursue common interests. **NSF**

12.0 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.

12.1 Software Productivity, Sustainability, and Quality Community of Practice (CoP)

The SPSQ CoP 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.

Agencies: CDC, DAF (AFRL), DHS (CISA, S&T), DOC (Census, NIST), DOD (DARPA, NSA, ONR, OUSD(R&E)), DOJ/NIJ, DOT (FAA), HHS (NIH, ONC), FBI, IARPA, NASA, NRC & NSF

12.1.1 Strategic Priorities & Associated Key Programs/Activities

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

- **Software Assurance Metrics And Tool Evaluation:** Provides standard data for flawed and fixed code through the Software Assurance Reference Dataset. **DARPA, IARPA, NIST, NSA & Census**
- **Combinatorial Testing:** Enables a mathematical selection of test attributes to reduce cost & increase effectiveness of high-assurance software testing circuit design. **NIST, NASA & OUSD(R&E)**
- **Health IT Testing:** Develops test methods and tools to ensure that health IT systems interoperate. **CDC & ONC**
- **Roots of Trust:** Conducts research and develops guidelines on the use of Roots of Trust to secure information and information systems. **DOD & NIST**
- **Assurance of Digital Engineering Models:** Enables rigorous model-based approaches for software assurance in support of a digital engineer approach. **AFRL**

- **Calculus and Metrics for Quantifying Coverage of Software Systems:** Increases software assurance in the design, development, automated testing and analysis, cases and certification. **AFRL**
- **Test Coverage Estimation for Max Operational Capability in Autonomous Systems:** Provides calculus and Metrics for Quantifying Coverage of Software Systems. **AFRL**
- **Tools to Quantify and Assure Software Development Cycle:** Increases software assurance in the design, development, automated testing and analysis, monitoring, and certification. **AFRL**
- **Software Assurance and Data Protection:** Develops data bill of materials, enhanced software assurance techniques, and software analysis technologies. **DHS S&T**
- **Aeronautics Research Mission Directorate (ARMD) University Initiatives:** Initiates interaction between NASA ARMD and the U.S. university community set their own research paths. **NASA**
- **NASA Engineering Safety Center:** Coordinates software engineering standards and practices across NASA. Reviews and reformulates software engineering standards with external agencies. **NASA**
- **Computational Model and Tool Development for Alzheimer's Disease Related Dementias:** Enables software tool development for biomarker discovery. **NIH**
- **Software and Hardware Foundation:** Supports potentially transformative research in the design, verification, operation, utilization, and evaluation of computer software and hardware. **NSF**
- **Digital Engineering approaches to software:** Improves effectiveness and applicability of digital technologies that drive acquisition and sustainment of systems. **OUSD(R&E)**

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

- **Performance of Scalable Systems:** Supports research to identify Software Abstractions for Parallelism targeting high-end heterogenous compute nodes at scale. **DOD, NIH, & NIST**
- **Applied Category Theory:** Integration and interoperability of application software and associated workflow tools to enable solving complex scientific and engineering problems. **NIST & NASA**
- **Web Image Processing Pipeline:** Supports an open-source web-based algorithmic platform for trusted image-based measurements using deep learning and computer vision techniques. **NIH & NIST**
- **Automated Vulnerability Identification Prioritization for Embedded Resources:** Supports the semi-automated software assurance toolchain to identify vulnerabilities in software. **AFRL**
- **Software Understanding for National Security and Critical Infrastructure:** Develops ability to perform technical analysis of national security and critical infrastructure software, at scale, to identify potential mission-threatening behavior. **DHS S&T**
- **Office of Safety and Mission Assurance Software Assurance Research Program:** Supports Independent Verification and Validation R&D to address software assurance problems. **NASA**
- **New Innovator Award Program:** Supports early-stage investigators of exceptional creativity who propose highly innovative research projects. **NIH**
- **Root & Rule-Based Technique:** Uses deep learning neural network and symbolic processing for terminology generation, information indexing, and searching documents. **NIST**
- **Secure and Trustworthy Cyberspace:** Solicits proposals that addresses cybersecurity and privacy, drawing on expertise in CISE, mathematics, and social, behavioral, and economic sciences. **NSF**
- **Software Foundations program:** Supports all aspects of Software Engineering and Deep Learning models and Large Language Models. **NSF**

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. *Also see EdW PCA Priority 7***.**

- **Development of training and career development for software assurance:** Supports development of training and career development for software assurance. **AFRL**
- **NASA Internship Program:** Offers internships to gain practical work experience while working with mentors who are research scientists, engineers, and other professions. **NASA**
- **NASA Space Technology Graduate Research Opportunities:** Supports innovative space technology research at respective campuses and at NASA Centers. **NASA**
- **CISE Research Initiative:** Supports early-career scientists at non-Carnegie R1 institutions in CISE enabling them to undertake exploratory research and develop collaborations & new approaches. **NSF**
- **ExLENT:** Aims to provide professionals in any field with an experiential learning opportunity that builds the skills and competencies they need to pivot into careers in key technologies. **NSF**
- **Faculty Early Career Development Program:** Supports faculty to serve as academic role models in research and education to lead advances in the mission of their department or organization. **NSF**
- **NSF Entrepreneurial Fellowships:** Helps make entrepreneurship more accessible for people in less-developed innovation ecosystems, expanding diversity & increasing participation of women and others underrepresented in STEM. **NSF**

Other NITRD Interagency Coordination Activity

13.0 Digital Health R&D (DHRD) IWG

The Digital Health Interagency Working Group coordinates R&D to improve the health of Americans by advancing technologies that support personalized health screening, monitoring, diagnosis, treatment, and prevention. The DHRD also facilitates broad access to healthcare information and resources and the building and sustainment of a diverse and highly skilled digital health workforce.

Agencies: DHS, DOC (NIST, NOAA), DOD, DOI/USGS, DOJ (FTC, NIJ), DOT, FCC, HHS (AHRQ, ASPE, ASPR, BARDA, CDC, CMS, FDA, NIOSH, OASH, ONC, SSA), NASA, NIH (Common Fund, NCI & NIDA), NSF, OPM, USDA-NIFA, USG & VA

13.1 Strategic Priorities & Associated Key Programs/Activities

1. Accelerate the R&D and implementation of next-generation accessible, interoperable, reconfigurable digital health tools, devices, and services and enable faster patient and provider access to novel technology and point-of-care services.

- **Clinical Decision Support Innovation Collaborative (CDSiC):** Advances evidence-based, interoperable Patient-Centered CDS to improve health outcomes through innovation. **AHRQ, CDC, CMS, FDA, NIH, ONC & VA**
- **CancerX:** Boosts innovation in cancer care through pre-competitive evidence generation, an accelerator program, and demonstration projects. **AHRQ, FDA, NIH, ONC & VA**
- **Cyber-physical Systems**: Advances the science of closed loop and human-in-the-loop systems to address medical and public health problems. **DOT, NIH, NSF & USDA-NIFA**
- **Home Test to Treat:** Facilitates home delivery of rapid tests, telehealth consultations, prescriptions, and medications. **ASPR & CDC**
- **Smart Health and Biomedical Research in the Era of Artificial Intelligence and Advanced Data Science:** Advances computing and engineering research to enhance health. **NIH & NSF**
- **Challenge on Designing the Optimal Future State of CDS Connect:** Seeks input on future CDS Connect and roles to identify models for sustaining and advancing it as a public resource. **AHRQ**
- **CDS Initiative:** Promotes Patient-Centered Outcomes Research CDS findings and develops tools for shareable, standards-based, and publicly available CDS artifacts. **AHRQ**
- **Examining the Impact of Artificial Intelligence (AI) on Healthcare Safety:** Invites applications on the impact of breakthrough AI on patient safety and safe implementation of AI systems. **AHRQ**
- **Using Innovative Digital Healthcare Solutions to Improve Quality at the Point of Care**: Invites proposals for research on digital healthcare interventions to enhance quality of care and service delivery at the point of care. **AHRQ**
- **Artificial Intelligence (AI) based algorithms to classify the Pneumoconioses:** Supports a framework for standardized patient work information to assist IT developers in implementing Occupational Data for Health (ODH) in systems like electronic health records. **NIOSH**
- **ODH:** Supports a framework for standardized patient work information to aid IT developers in collecting ODH data in systems like electronic health records. **NIOSH**
- **Health IT at NIST**: Boosts health IT interoperability by advancing standards, developing testing infrastructure, supporting certification, and exploring new security and technology protocols. **NIST**
- **Internet of Things in Health Care:** Supports research on wearables, implants, and ingestible microelectronics to develop IoT frameworks, testbeds, and models for health data communication between patients and health IT systems. **NIST**

- **Leading Edge Acceleration Projects in Health Information Technology:** Addresses fast emerging challenges that inhibit the development, use, and advancement of interoperable health IT. **ONC**

2. Promote innovation and workforce development in digital health to reduce health disparities, enhance equity, and achieve better health outcomes for all.

- **Creating a Digital Healthcare Equity Framework With an Accompanying Guide for Its Use:** Helps creators and users of healthcare solutions that involve digital technologies ensure that their solutions are equitable. **AHRQ, CMS, FDA, OASH & ONC**
- **Expanding AI Innovation through Capacity Building and Partnerships:** Supports projects and partnerships in the National AI Research Institutes to broaden participation in AI research, education, and workforce development. **DHS, DOD, NIST, NSF & USDA-NIFA**
- **Pediatric Medical Device Public Private Partnership:** Develops a pediatric medical device ecosystem to reduce risk and encourage the development and commercialization of devices. **BARDA, FDA, NIH & industry partner**
- **Data Science Corps:** Focuses on building capacity for harnessing the data revolution at the local, state, and national levels to help unleash the power of data in the service of science and society. **NSF, academic & industry partners**
- **Evaluation Datasets as Medical Device Development Tools for Testing Cancer Technologies Small Business Innovation Research:** Aims to help incentivize the small business community to develop and qualify innovative tools for oncology-related regulatory decision-making. **FDA & NCI**
- **Streamlining Emerging Technology Medical Device Development Through Regulatory Tools:** Facilitates innovation in medical device regulation and basic science, focusing on emerging technologies and interoperability. **FDA & VA**
- **Harnessing Data Visualization to Advance Equity in Clinical Services:** Accelerates identifying and addressing inequities in preventive services through EHR interoperability/visualization across health systems. **AHRQ**
- **Impact of Healthcare Algorithms on Racial and Ethnic Disparities in Health and Healthcare**: Supports in-progress evidence reports examining the evidence on computer algorithms and racial and ethnic bias in healthcare, and approaches to mitigate such bias. **AHRQ**
- **Transformative Research to Address Health Disparities and Advance Health Equity:** Supports innovative, translational research projects to prevent, reduce, or eliminate health disparities and advance health equity. **NIH**
- **Toward Wellness Medicine: The P9 Approach:** Develops standards and testing tools for integrating genomic data and metadata into EHRs. **NIST**
- **ExLENT:** Aims to provide professionals in any field with an experiential learning opportunity that builds the skills and competencies they need to pivot into careers in key technologies. **NSF**
- **MSIs Research Expansion Program:** Accelerates identifying and addressing inequities in preventive services through EHR interoperability and visualization across health systems. **NSF**
- **NSF Entrepreneurial Fellowships:** Helps make entrepreneurship more accessible for people in less-developed innovation ecosystems, expanding diversity and increasing participation of women & others underrepresented in STEM. **NSF**
- **Public Health Informatics & Technology Workforce Development Program:** Aims to strengthen U.S. public health IT efforts, improve COVID-19 data collection, and increase representation of underrepresented communities within the public health IT workforce. **ONC**

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

- **Building the Proto-OKN:** Seeks to build a Proto-OKN prototype with three themes: developing knowledge graphs for societal challenges, creating the technical infrastructure to link these graphs, and producing educational materials and tools. **NASA, NIH, NIJ, NOAA, NSF & USGS**
- **Code Map Services for Interoperability of Common Data Models (CDMs) & Data Standards:** Facilitates CDM network interoperability, thereby expanding researchers' access to clinical data that can be used for addressing new questions across a range of populations and settings. **ASPE, FDA & NIH**
- **Semantic Interoperability of Medical Devices:** Facilitates the development and adoption of medical device communication standards and their integration into electronic health records. **FDA, NIH & NIST**
- **Diagnostic Data Exchange-The Opportunity Project Sprint:** Aims to tackle four challenges that center on improving the quality and utility of diagnostic data – from tests used anywhere – to improve health. **Census & FDA**
- **National AI Research Resource 2020:** Calls for a public-private effort to build research infrastructure that supports next-gen AI, strengthens the U.S. innovation ecosystem, and safeguards privacy and civil rights. **NSF & USG**
- **Center for Evidence and Practice Improvement Evidence Discovery and Retrieval Project:** Makes AHRQ's Patient-Centered Outcomes Research findings more FAIR with clinician and researcher-friendly technologies and develops a prototype for standards-based, API-enabled discovery and retrieval. **AHRQ**
- **Health Informatics - Personal Health Device Communication - Device Specialization - Home Healthcare Environment Ventilator:** Standardizes data from spirometers to enable vendor-agnostic software tools like AI for patient diagnosis, management, and respiratory disease research. **NIOSH**
- **NIOSH Industry and Occupation Computerized Coding System:** Uses AI/ML to convert industry and occupation text in surveys, death certificates, and medical records into standardized codes for analyzing health-work relationships. **NIOSH**
- **End-to-End Test Platform**: Supports experts in creating messaging guides, test cases, and validation test sites for conformance and interoperability. **NIST**
- **Image-Based Quality Control of Retinal Pigment Epithelial Implants:** Focuses on defining image-based quality criteria for stem cell-based therapy. **NIST**
- **Mobile Access to Health Documents Fast Healthcare Interoperability Resources Toolkit**: Builds upon the existing Cross Document Exchange "(XDS) Toolkit" to provide a base operating environment that targets testing of the HL7 FHIR standard. **NIST**
- **CISE Community Research Infrastructure:** Supports research infrastructure for diverse CISE communities focusing on computer and information science and engineering. **NSF**

4. Support the integration and use of digital health technologies within healthcare and public health systems to understand and mitigate the impacts of changes in climate and the environment on health.

- **Validation of Digital Health and Artificial Intelligence Tools for Improved Assessment in Epidemiological, Clinical, and Intervention Research Notice of Special Interest (NOSI):** Supports the evaluation of the utility and validity of digital health and AI tools and technologies in epidemiological, clinical, and intervention research. **NIH**
- **The Veterans Cardiac Health and AI Model Predictions challenge:** Promotes understanding of AI/ML models and synthetic data to improve heart failure outcomes in veterans, using synthetic data to develop and refine these models. **FDA, NIH, NIST, VA, industry & international partners**
- **Data at Rest Quality Management Tool:** Analyzes Immunization Information System data per NIST specifications to produce measurements and detect quality issues related to accuracy, validity, completeness, timeliness, and uniqueness. **CDC, NIST & association**
- **Expanding Climate Change & Health Data Infrastructure to Advance Health Interventions:** Identifies, catalogs, and links health and environmental data and provide resources and datasets to explore use cases focused on wildfires and the health impacts of climate change. **ASPE & NIH**
- **Incorporating Human Behavior in Epidemiological Models:** Provides more reliable modeling tools to inform decision making and to evaluate public health policies during pandemics and other public health crises. **NIDA & NSF**
- **Bridge2AI** Generates new data sets and tools that promote FAIR principles. **NIH**
- **United States Core Data for Interoperability (USCDI) + Public Health:** Addresses public health data needs beyond USCDI; focusing on surveillance, lab data, multi-directional exchange, maternal and child health, and health equity. **ONC**

5. Develop appropriate privacy-preserving methods, strategies, and standards to enhance trust and confidence in digital health technologies.

- **PDaSP:** Enhances the ability to privately share and analyze data for a range of use cases and applications to solve real world problems. **DOT, FHWA, NIST & NSF**
- **AI Institutes:** Advances AI that is trustworthy across arrange of domains, including health. **NSF & other federal agencies**
- **Safe Learning Enabled Systems**: Enhances the safety of AI systems. **NSF & non-profit organization**
- **Admin Supplement for Research & Capacity Building Efforts Related to Bioethical Issues NOSI**: Supports research on bioethical issues to inform policy & enhance bioethics research capacity. **NIH**
- **National Firefighter Registry (NFR) for Cancer**: Seeks firefighters to join the NFR to better understand and reduce the cancer rate among US firefighters. **NIOSH**
- **Cybersecurity of Genomic Data**: Conducts research to identify genomic data cybersecurity and privacy concerns and develops guidance to address these challenges. **NIST**
- **Mitigating Cybersecurity Risk in AI Enabled Healthcare Applications:** Researches AI-enabled healthcare applications, like diagnostic image interpretation and digital scribes, focusing on cyber risk and privacy concerns. **NIST**
- **Mitigating Cybersecurity Risk in Telehealth Smart Home Integration:** Supports the identification of threats and risks to the smart home integrated telehealth ecosystem. **NIST**
- **Securing Telehealth Remote Patient Monitoring Ecosystem:** Allows patients with chronic or recurring conditions to have continuous monitoring and treatment from care providers while in their homes. **NIST**

- **Secure and Trustworthy Cyberspace:** Includes securing and privacy protections for biomedical and public health systems. **NSF**