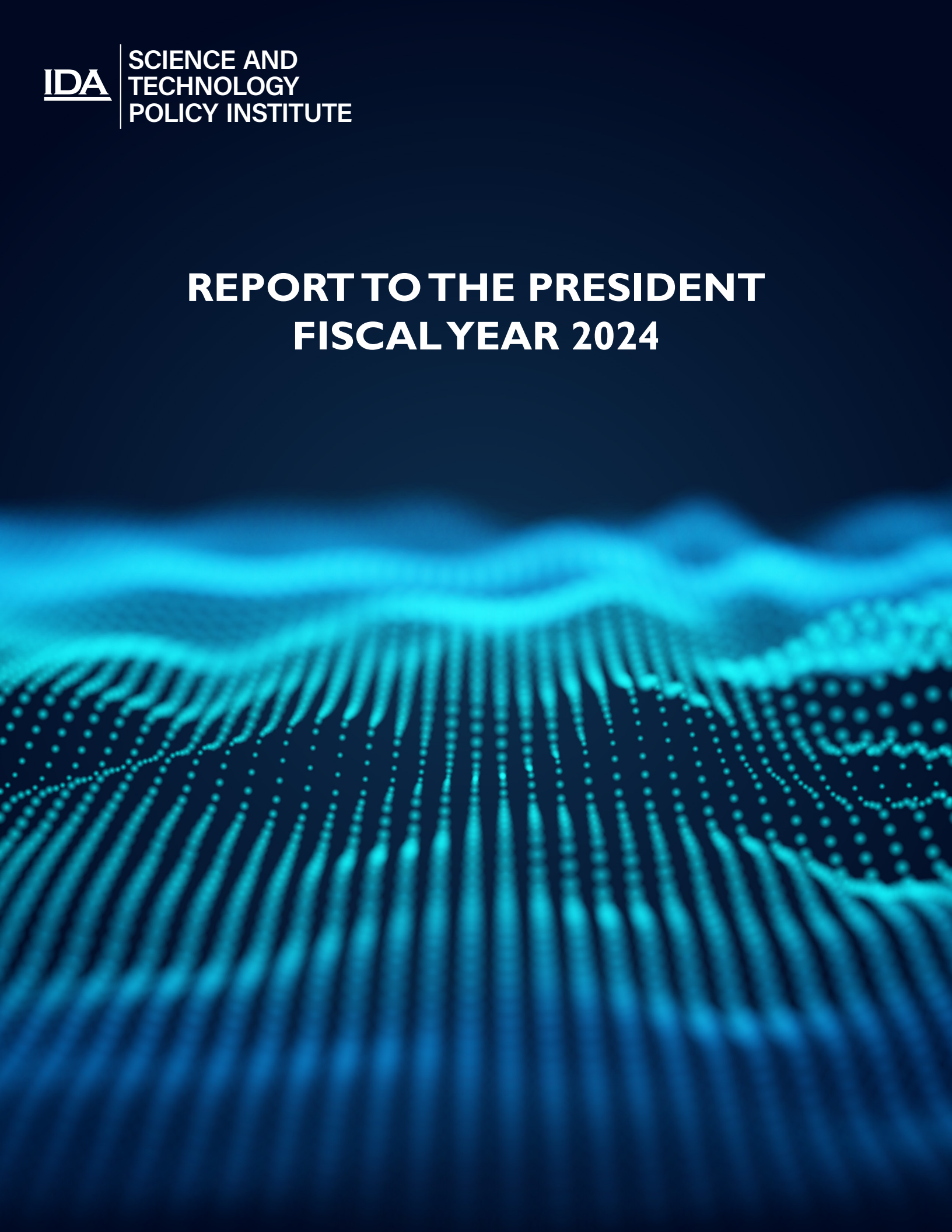
IDA SCIENCE AND TECHNOLOGY POLICY INSTITUTE

REPORT TO THE PRESIDENT FISCAL YEAR 2024



The Institute for Defense Analyses is a nonprofit corporation that operates three Federally Funded Research and Development Centers. Its mission is to answer the most challenging U.S. security and science policy questions with objective analysis, leveraging extraordinary scientific, technical, and analytic expertise.

REPORT TO THE PRESIDENT
FISCAL YEAR 2024

LETTER FROM THE DIRECTOR

Dear Mr. President:

On behalf of the IDA Science and Technology Policy Institute (STPI), I am proud to present our report of activities for fiscal year 2024. For more than two decades, STPI has been operated by the nonprofit Institute for Defense Analyses with sponsorship through the National Science Foundation.

Congress established STPI as a federally funded research and development center in 1991 to inform policy decisions of the Office of Science and Technology Policy (OSTP) in the Executive Office of the President (EOP). In 1998, it expanded STPI's mission to include:

- Reporting on significant trends and developments in science and technology in the United States and abroad,
- Analyzing those trends with attention to the Federal science and technology portfolio, and
- Performing studies that will ensure the long-term strength of American science and technology.

With the encouragement of the Director of OSTP, STPI also works with other Federal agencies to inform science and technology policies and assess their effectiveness, including the National Science Foundation, the National Aeronautics and Space Administration, the National Institutes of Health, the Department of Energy, and the Department of Labor. In addition, we have helped OSTP provide support for the President's Council of Advisors on Science and Technology and other EOP bodies such as the National Coordination Office of the Networking and Information Technology Research and Development Program and the U.S. Global Change Research Program.

This report showcases how STPI's researchers and fellows apply deep knowledge and creative solutions to keep OSTP and Federal agencies abreast of a wide variety of science and technology trends and topics. Everyone at STPI is deeply committed, both individually and as an institution, to providing OSTP and Federal agencies rigorous, objective analysis with complete discretion and free of conflicts of interest. On behalf of everyone at STPI, we are proud of our work helping ensure that the United States continues to lead the world in discovery, innovation, and technological progress and that the American people continue to benefit from the Nation's long-standing and forward-looking investment in science and technology.

Kristen M. Kulinowski

ABOUT THE SCIENCE AND TECHNOLOGY POLICY INSTITUTE

The Science and Technology Policy Institute (STPI) was established by Congress in the National Defense Authorization Act for Fiscal Year 1991 (P.L. 101-510) as a federally funded research and development center (FFRDC) under the name Critical Technologies Institute. In 1998, Congress renamed the Institute as part of the National Science Foundation Authorization Act of 1998 (P.L. 105-207), which also assigned STPI the following duties:

- Assembly of timely and authoritative information regarding significant developments and trends in science and technology research and development in the United States and abroad.
- Analysis and interpretation of the information with particular attention to the scope and content of the Federal science and technology research and development portfolio as it affects interagency and national issues.
- Initiation of studies and analyses of alternatives available for ensuring the long-term strength of the United States in the development and application of science and technology.
- Provision, upon the request of the Director of the White House Office of Science and Technology Policy (OSTP), of technical support and assistance
  - to committees and panels of the President's Council of Advisers on Science and Technology, and
  - to interagency committees and panels of the Federal Government concerned with science and technology.

Consistent with congressional direction, STPI provides analyses of significant science and technology policies and developments in the United States and abroad for OSTP, its primary sponsor, and for other Federal Government organizations with science and technology responsibilities. To ensure the continued relevance of its work, STPI meets frequently with the Director and staff of OSTP. Such close coordination—coupled with a flexible tasking process—ensures that STPI focuses on OSTP's top priorities and emergent problems.

To address STPI's broad science and technology charter, STPI researchers possess educational training and professional experience across the spectrum of disciplines and sectors. The majority of degrees among STPI's research staff are in mathematics, physical and life sciences, and engineering, with law, social science, communication, and history rounding out the staff's educational background.

CONTENTS

FEDERAL SCIENCE AND TECHNOLOGY ENTERPRISE

Interagency Coordination of Research and Development Infrastructure

This project provided ongoing support to the National Science and Technology Council (NSTC) Research and Development Infrastructure Subcommittee and its working groups, answering research questions of interest to its members and contributing to the subcommittee's preparation of reports. The Science and Technology Policy Institute (STPI) actively supported the preparation of a report titled *U.S. Federal Research and Development Infrastructure: A Foundation of the Nation's Global Scientific Leadership and Economic and National Security* that the NSTC published in May 2024. STPI also supported development of the Data Infrastructure Working Group's report, titled *Framework for Considering Data Infrastructure and Interconnectivity in and among Research and Development Infrastructure Projects*.

Analysis of International R&D Infrastructure Plans

The NSTC Subcommittee on Research and Development Infrastructure advises and assists the NSTC on the coordinated development of Federal research and development (R&D) infrastructure, including policies, at Federal laboratories. The Office of Science and Technology Policy (OSTP) and the subcommittee asked STPI to ingest and synthesize information received from U.S. embassies around the world in response to a U.S. Department of State Démarche requesting information on future R&D infrastructure plans of host countries. STPI's summary was used to inform a 2024 report prepared by the subcommittee on the U.S. competitive position in R&D infrastructure, titled U.S. *Federal Research and Development: A Foundation of the Nation's Global Scientific Leadership and Economic and National Security*.

Supporting the Committee on Foreign Investment in the United States

The Committee on Foreign Investment in the United States (CFIUS) is an interagency committee authorized to review certain transactions involving foreign investments in the United States and certain real estate transactions by foreign persons, in order to determine the effect of such transactions on the national security of the United States. OSTP is a CFIUS member agency. STPI works with OSTP to inform their ongoing review of CFIUS transactions as well as other workflows.

Examining the National Strategic Computing Reserve

The National Strategic Computing Reserve (NSCR) emerged from the success of the High-Performance Computing Consortium that brought together the Federal Government, industry, and academic leaders to provide access to the world's most powerful high-performance computing resources in support of research to address the COVID-19 pandemic. The NSCR is meant to provide computing resources and deliver research expertise in times of crisis to help save lives, property, public health, and to lessen or avert the threat of a catastrophe. OSTP asked STPI to conduct a scenario-based Tabletop Exercise (TTX) to see how the NSCR could be realized and implemented in a time of crisis, including the roles of various Federal agencies

and the infrastructure needed for efficient agency coordination. STPI developed three exercises to examine the NSCR through the lens of two scenarios, and then conducted a full day TTX with participants from nine government agencies, three federally funded R&D centers, and two academic institutions. STPI produced an after-action report that outlined roles for the NSCR as an information repository, a coordinating entity, and as a communicator of advanced computing capabilities for disasters; noted gaps in the existing scope of the NSCR; identified gaps in agency authorities for cooperation as a major obstacle to success; suggested that a tactical TTX in the style of a Federal Emergency Management Agency exercise be conducted; and recommended that additional stakeholders such as industry, academics, and disaster subject matter experts be brought on board.

Evaluating the Efficacy of the Research Security Training Modules for the U.S. Research Community

In January 2024, the U.S. National Science Foundation (NSF) launched research security training (RST) modules to help U.S. universities meet new research security requirements articulated in the Creating Helpful Incentives to Produce Semiconductors (CHIPS) and Science Act and National Security Presidential Memorandum 33. STPI has supported NSF by developing and fielding an online survey of U.S. universities to investigate the awareness of, satisfaction with, and plans for deployment of RST modules. When analysis of the survey responses is completed, the feedback about the modules will help NSF determine whether any changes to their content or deployment are warranted.

Supporting the Assessment of Engines Program Deliverables

The NSF Engines program aims to fund regional coalitions of partnering organizations that will catalyze technology and science-based regional innovation ecosystems. Each Engine is focused on addressing specific aspects of a major societal and/or economic challenge that are of significant interest in the Engine's defined "region of service." Each Engines awardee is tasked to develop a strategic and implementation plan to ensure proper organization, management, and planning to sustain the Engine. STPI was asked to develop rubrics to integrate with NSF's assessment and evaluation framework, which is designed to holistically measure the NSF Engines program over the entire 10-year period of an award. In addition, STPI was asked to provide training to NSF program staff to implement the rubrics and conduct programmatic-level assessments.

Assistance on the FY21–22 Implementation of Federal Prize and Citizen Science Authority

The America Creating Opportunities to Meaningfully Promote Excellence in Technology, Education, and Science (COMPETES) Reauthorization Act of 2010 granted broad authority to all Federal agencies to conduct prize competitions to encourage fresh perspectives, novel approaches, and collective problem-solving to spur innovation and ingenuity. The complementary American Innovation and Competitiveness Act, which became law in January

2017, gave Federal agencies broad authority to use crowdsourcing—and specifically citizen science—to advance agency missions and facilitate broad public participation in the innovation process. OSTP is required by these Acts to submit a biennial report to the Committee on Commerce, Science, and Transportation of the Senate and the Committee on Science, Space, and Technology of the House of Representatives on the activities carried out under these two authorities. STPI assisted OSTP in 2024 with submitting the FY21–22 biennial report to Congress by gathering and compiling information on prize competitions and crowdsourcing/citizen science projects conducted by Federal agencies.

Analysis of the Cost for a New U.S. Deep Sea Drilling Ship

The International Ocean Discovery Program (IODP) is the most recent manifestation of a five-decade research program to explore Earth's evolution and structure as recorded in the ocean basins. NSF's primary contribution to IODP since the 1980s has been the JOIDES Resolution (JR), a deep-ocean drilling vessel. NSF has chosen not to renew its cooperative agreement with the vessel's science operator due to rising costs and the inability of international partners to contribute support. As a result, JR operations as an NSF-provided research platform ended in September 2024. NSF asked STPI to provide a cost analysis for a future scientific ocean drilling vessel taking into account a set of mission requirements developed by the scientific community. STPI has compiled data on construction and operation costs of an array of modern vessels that share various traits with a deep-ocean drilling vessel capable of meeting the scientific community's priorities; conducted interviews with experts in naval architecture, drill rig design, and vessel operation; and toured the JR in port as well as other modern vessels with drilling capabilities. STPI's report delivered to NSF provides a cost assessment and documents the factors affecting construction and operation expenses for a new scientific drilling vessel.

Assistance with Federal Scientific Integrity Policy and Practice

The President issued a *Memorandum on Restoring Trust in Government Through Scientific Integrity and Evidence-Based Policymaking,* which set in motion a series of government-wide activities that produced the *NSTC Framework for Federal Scientific Integrity Policy and Practice* and established the NSTC Subcommittee on Scientific Integrity (SOSI). Since the Framework's release, agencies have been working to develop, share, and finalize their scientific integrity (SI) policies, several of which have already been publicly posted. The Memorandum directed OSTP to develop and publish a biennial report on the progress of Federal SI policies and practices. STPI was asked by OSTP to assist with coordinating the collection of information on SI implementation from Federal agencies and analyzing and summarizing the information collected through the SOSI data call. STPI also assisted OSTP with preparation of the biennial report, which was released in July 2024.

Supporting the Federal Environmental Justice Science, Data, and Research Plan

Executive Order (EO) 14096, *Revitalizing Our Nation's Commitment to Environmental Justice for All,* identified the need for actions across the whole of government—including those related to science, data, and research—to advance environmental justice. The EO charged OSTP, in consultation with the Chair of the White House Council on Environmental Quality (CEQ), to establish an Environmental Justice Subcommittee under the NSTC and develop a coordinated *Environmental Justice Science, Data, and Research Plan*. OSTP asked STPI to analyze responses to a *Request for Information (RFI) to Support the Development of a Federal Environmental Justice Science, Data, and Research Plan*. The results of STPI's analysis were used to inform the Research Plan, which provides principles, information, and resources that can assist agencies in advancing the goals of the EO in their activities related to science, data, and research consistent with applicable law and as appropriate under their respective authorities and missions.

Assistance with the Workshop on Bias, Discrimination and Hate Crimes

OSTP, along with the National Security Council (NSC) and the Domestic Policy Council (DPC), was charged in the *U.S. National Strategy to Counter Antisemitism* with launching an interagency effort to understand and eliminate the impediments to reporting hate incidents. This effort is intended to complement existing initiatives and investments aimed at improving awareness of hate and bias-related incidents experienced in many communities across the country with the goal of informing current and future evidence-based policies and programs. The goal of the effort is to further understand the social, behavioral, and structural barriers that limit the ability to address these incidents. The White House held a workshop on *Advancing Understanding of Hate and Bias-Related Incidents*—primarily organized by OSTP, NSC, and DPC—that brought together experts on hate crimes. STPI facilitated the participation of these researchers and the development of a report to inform future research directions on hate crime and hate crime reporting.

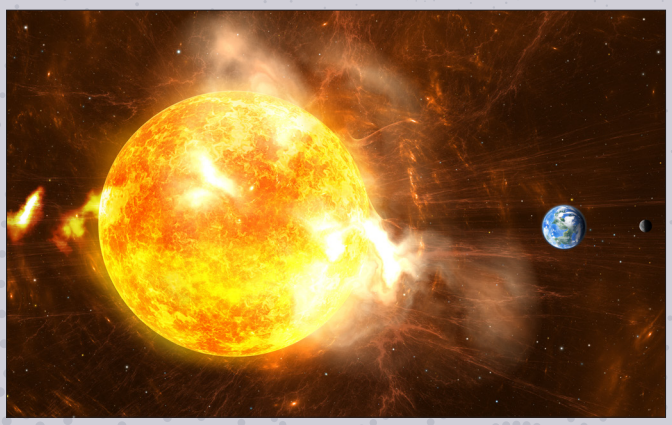
Support for PCAST

The President's Council of Advisors on Science and Technology (PCAST) is an advisory group composed of "distinguished individuals and representatives" from industry, academia, and nonprofits with "diverse perspectives and expertise in science, technology, and innovation." PCAST advises the President "on matters involving policy affecting science, technology, and innovation, as well as on matters involving scientific and technological information that is needed to inform public policy relating to the economy, worker empowerment, education, energy, the environment, public health, national and homeland security, racial equity, and other topics." OSTP asked STPI to provide technical support to PCAST in the form of background research, information gathering and analysis, identification of key issues for PCAST consideration, and technical review and writing support. STPI provided support to PCAST and its working groups, including technical input, writing, or review for four of the five PCAST reports released in FY24:

1. *Letter on Recommendations for Expanding STEM Talent in the Federal Workforce,*
2. *Report on Recommendations for Advancing Nutrition Science,*
3. *Report on Recommendations for Supercharging Research: Harnessing Artificial Intelligence to Meet Global Challenges, and*
4. *Report on Recommendations for Strategy for Cyber-Physical Resilience.*

STPI researchers continue to conduct analyses and assist in report development for PCAST and its current working groups on review of the U.S. Networking and Information Technology R&D Program, social sciences, and the future of groundwater.

SPACE TECHNOLOGY AND POLICY



Examining Cislunar Governance

In November 2022, OSTP released the first *National Cislunar Science and Technology Strategy* to advance U.S. leadership in cislunar space, which includes as a key objective the expansion of international science and technology cooperation to "foster peace, develop responsible practices, and create the foundations for new institutions to enable enduring human and robotic presence in cislunar space." The strategy amplifies ongoing work to advance the Artemis Accords, a U.S.-led initiative to put in place a common set of principles to govern the civil exploration and use of outer space. However, with an expanding list of nations planning and carrying out activity in cislunar space, to include the lunar surface, principles to guide cooperative work are increasingly needed. OSTP asked STPI to study what rules-based governance frameworks could be pursued. To fully explore possible cislunar governance mechanisms, STPI reviewed existing literature, conducted several interviews, and hosted a Space Forum to identify what aspects of lunar governance are priorities to a future cislunar environment.

Support for Space Weather Advisory Group

The NSTC Subcommittee on Space Weather Operations, Research and Mitigation (SWORM) has an advisory committee, the Space Weather Advisory Group (SWAG), composed of 15 members from the academic, commercial, and space weather end user communities. The SWAG is required to "conduct a comprehensive survey of the needs of users of space weather products to identify the space weather research, observations, forecasting, prediction, and modeling advances required to improve space weather products." The SWAG Chair, in coordination with OSTP and the SWAG Designated Federal Officer, requested STPI's assistance to (1) collect data; (2) summarize results; and (3) draft a report for further consideration by the SWAG. STPI helped conduct a set of focus groups and collected inputs across nine sectors of the space weather community on improving the ability of the United States to prepare for, mitigate, respond to, and recover from space weather storms.

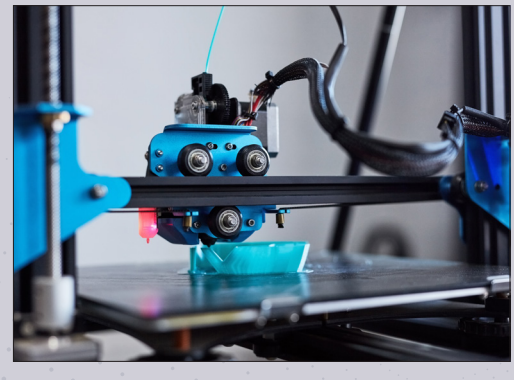
Technical and Analytical Support for OSTP Space Weather Activities

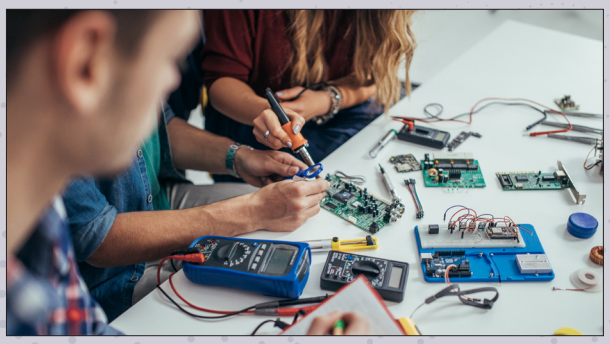
Space weather encompasses a wide array of phenomena that can have severe effects on national security assets and the Nation's critical infrastructure, including assets in space. Through coordination across the Federal Government and sustained engagement with academia, the private sector, and international partners, the United States has made significant progress in enhancing preparedness over the past decade. To address the threat posed by space weather, Congress passed the bipartisan Promoting Research and Observations of Space Weather to Improve the Forecasting of Tomorrow (PROSWIFT) Act in October 2020. PROSWIFT codified coordination of space weather research and forecasting within the Federal Government through SWORM. STPI has provided support to OSTP and NSTC by helping coordinate SWORM activities, assisting the efforts of a Fast Track Action Committee (FTAC) on the Space Weather Scales, and coordinating input from stakeholders regarding updates to Space Weather Scales and benchmarks.

Analysis of the Space Weather Scales

To communicate current and future space weather conditions and possible effects on people and systems, the National Oceanic and Atmospheric Administration introduced the Space Weather Scales in 1999. The scales characterize three space weather phenomena—geomagnetic storms, solar radiation storms, and solar flare x-ray emissions—that can imperil physical infrastructure and assets as well as human health. Society's increased reliance on systems that can be impacted by space weather warrants a careful consideration for the revision and improvement of space weather hazard communications, including the Space Weather Scales. One of the three objectives in the *2019 National Space Weather Strategy and Action Plan* calls for the Federal Government to work with partners to enhance the protection of national security, homeland security, and commercial assets and operations against the effects of space weather. In response, STPI is conducting a study on the Space Weather Scales to help review, revise, and make available, as appropriate, the Space Weather Scales for use by the United States, other nations, and the international space weather community. The revision will be informed by the needs and interests of key stakeholders across the national and international public, private, academic, and the non-governmental organization communities.

STEM EDUCATION, WORKFORCE, AND TALENT





Assistance with Federal STEM Strategic Plan

The COMPETES Act of 2010 requires NSTC's Committee on Science, Technology, Engineering, and Mathematics (STEM) to prepare and implement a STEM strategic plan on a regular 5-year cycle. OSTP asked STPI to support the efforts of the Committee on STEM and its subcommittee, Federal Coordination on STEM (FC-STEM), in the preparation of the next Federal STEM strategic plan. Over the course of this effort, STPI has provided extensive support for numerous information-gathering events including listening sessions, roundtables, focus groups, and a townhall. In FY24, STPI's role was centered around facilitating writing teams composed of Federal agency representatives and synthesizing deliberations to inform the plan's development. In addition, STPI has supported the review and revision process by compiling feedback from across participating agencies represented on FC-STEM and convening an FC-STEM focus group during the initial round of review.

Analysis of Safe and Inclusive STEM Environments

The NSTC's Committee on STEM established the Interagency Working Group on Safe and Inclusive STEM Environments (IWG-SISE) in response to the CHIPS and Science Act for the purpose of coordinating Federal research agency efforts to reduce the prevalence of sex-based and sexual harassment. OSTP asked STPI to help IWG-SISE develop an inventory of Federal research agency policies, procedures, resources, and activities related to sex-based and sexual harassment involving both Federal employees and non-Federal employee research award personnel. OSTP submitted the inventory to Congress and published it on its website in February 2024. In addition, STPI analyzed the policies included in the inventory and determined their relevance to the CHIPS and Science Act. STPI's work informed the IWG-SISE's ongoing efforts to develop policy guidelines to reduce sexual harassment by awardees for Federal agencies that fund extramural research.

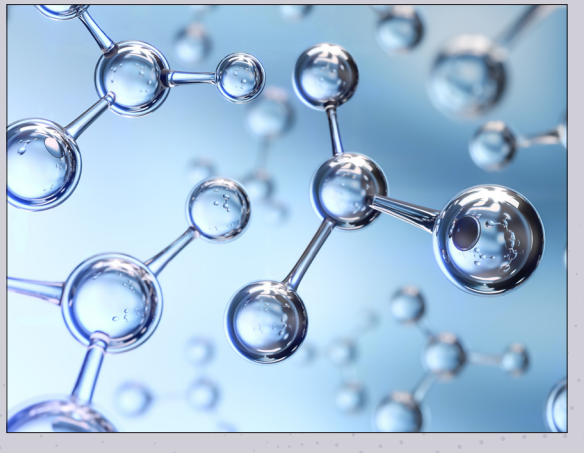
Charting the Course for STEM Education of the Future

NSF's Directorate for STEM Education seeks to achieve excellence in U.S. STEM education for all ages and in all settings. That excellence undergirds a well-prepared workforce of scientists, technicians, engineers, mathematicians, and educators and a well-informed citizenry. NSF asked STPI to support NSF staff engaging with representatives of the STEM education R&D community and other STEM education stakeholders to explore possible future directions and venues for STEM learning and education and for the purpose of creating partnerships among educators, researchers, private foundations, and businesses. In 2024, STPI supported two workshops on CAREER awardees and Hispanic STEM learning. In addition, STPI carried out analyses related to developing research capacity at Historically Black Colleges and Universities. All products were used by NSF as part of its internal strategic deliberations regarding future programmatic efforts.

Space STEM Workforce Analysis and Analysis of Tools and Methods for Sourcing Skills Data

OSTP asked the Department of Labor (DOL) to provide information about what an effort to build rockets and vehicles for transporting personnel and materials to build a base on the Moon might require. DOL possesses multiple sources of data on the current workforce in various industries, including skills required, tasks performed, and projected future employment, but it does not generate hypothetical scenario-based projections of skill needs based on future goals. STPI was asked to consider potential future workforce needs based on existing aerospace workforce data. DOL also sought to explore and test the use of emerging methods—including those using artificial intelligence (AI)—to make collection and interpretation of data more efficient in the evaluation of skills for new and emerging critical occupations in the science and technology workforce. STPI first reviewed existing literature to establish a set of working definitions of the space STEM workforce, which was used to identify space-specific STEM skills. STPI then explored Federal databases of skill-level workforce information as well as accessible data on job postings to determine what occupations require skills relevant to space STEM work. STPI then engaged in a landscape analysis and pilot study of AI-enabled labor data platforms that could provide DOL information on skills relevant to space STEM work and other emerging technologies.

BIOSCIENCES AND PUBLIC HEALTH



Pandemic Innovation

OSTP asked STPI for research and analysis to inform the development of mechanisms to reduce the emergence of antimicrobial resistant microbes. Antimicrobial resistance can emerge from multiple sources, including the discharge of antimicrobial products and derivatives into the environment. The United Kingdom (U.K.) has developed regulations concerning the discharge of waste products from companies manufacturing active pharmaceutical ingredients—the precursors to antibiotics—into the environment. OSTP asked STPI to conduct rapid research and analysis to understand the feasibility of adopting similar waste management approaches in the United States or other international facilities and to summarize findings into a series of short documents. The first document summarized U.K. antibiotic use, manufacturing capabilities, waste management practices, and incentives to adopt waste management practices. The second document summarized information gathered about antibiotic use, manufacturing, and waste management practices in the United States and examined the feasibility of adopting U.K. approaches. The third and fourth documents examined antibiotic use, manufacturing capabilities, and waste management practices in Brazil and India, respectively, as well as the feasibility of adopting U.K. standards in local manufacturing facilities. This work was used to inform OSTP's conversations at the United Nations General Assembly High-Level Meeting on Antimicrobial Resistance.

Developing Information on a Potential Rule Involving Omic Data

EO 14117, *Preventing Access to American's Bulk Sensitive Personal Data and United States Government-Related Data by Countries of Concern,* issued in 2024, expands the scope of the national emergency declaration outlined in EO 13873, *Securing the Information and Communications Technology and Services Supply Chain*. EO 14117 tasks the Attorney General, along with the Secretary of Homeland Security and other relevant agencies, with issuing regulations that prohibit or restrict U.S. persons from engaging in transactions that could enable countries of concern to access U.S. persons' sensitive or U.S. Government-related data. Section 5 of the EO requires NSC, DPC, OSTP, and the Office of Pandemic Preparedness and Response (OPPR) to submit a report to the President that evaluates the risks, costs, and benefits of regulating transactions involving human omic data and other genomic data. OSTP asked STPI to gather information on the potential impact a new rule regulating transactions of bulk human omic data would have on R&D, the bioeconomy, health outcomes, pandemic preparedness, and U.S. competitiveness. To fulfill this request, STPI conducted informational interviews, synthesized peer-reviewed literature, surveyed stakeholders, and obtained data from clinical trials and international publications. Findings were summarized in a final report and final briefing for the Executive Office of the President (EOP). STPI also presented its findings to interagency colleagues involved in the rulemaking process.

Developing Information on Bioeconomy Engagement

The EO on *Advancing Biotechnology and Biomanufacturing Innovation for a Sustainable, Safe, and Secure American Bioeconomy* is intended to coordinate a whole-of-government approach to advance biotechnology and biomanufacturing in areas related to health, climate

change, energy, food security, agriculture, supply chain resilience, and national and economic security. Section 8 of the EO calls for the heads of agencies, in coordination with OSTP, to identify areas of ambiguity, gaps, and uncertainties in the *2017 Update to the Coordinated Framework for the Regulation of Biotechnology*. The EO directs the agencies to conduct horizon scanning and stakeholder engagement to inform regulatory updates and requires that they develop a plan to implement regulatory updates. In support of this effort, STPI facilitated an event during which product developers tested a decision tree intended to help streamline the regulation of genetically modified microbes. STPI also conducted interviews with product developers, academic researchers, trade organizations, and non-governmental organizations to obtain feedback on how the Coordinated Framework could be modified to streamline the regulatory review of biotechnology products, specifically plant-incorporated protectants and modified microbes. STPI summarized its findings into an interim briefing for OSTP and interagency regulatory partners. The work is being used to inform potential changes in the modified microbe decision tree and updates to the Coordinated Framework.

Software Verification for Cloud Laboratories and Biofoundries

The integration of software systems, AI, and robotics into the life sciences R&D ecosystem has the potential to accelerate a U.S.-based advanced biosciences economy. The coupling of biological data, software dependent manufacturing, and, in some cases, AI, yields capabilities that are deeply and inherently dual use. Ensuring the safety and security of these novel facilities, data, and computational methods and architectures is a critical and emerging national security concern since both benign and malicious actors can potentially access these tools. OSTP asked STPI to characterize the opportunities and challenges associated with application of formal methods for software verification for advanced biosciences applications. STPI analyzed the landscape of applications of formal methods for software verification through a review of published literature and interviews with subject matter experts. STPI's research summarized the range of opportunities and challenges to adoption of formal methods as a means of securing the software underpinning cloud laboratory and biofoundry infrastructure.

Opportunities for Applications of Bioelectronics to Biodefense

Bioelectronic medicine refers to a growing body of medical technologies that involve non- or minimally invasive approaches to leveraging nervous system activity for therapeutic and diagnostic needs. OSTP requested that STPI conduct a landscape analysis of potential applications of bioelectronic medicine to biodefense and provide policy expertise to consider how findings might be incorporated into relevant national strategies and implementation mechanisms. STPI conducted interviews with experts and performed literature reviews on a variety of use cases for bioelectronic medicine. This information was used to develop an interim briefing on potential policy and implementation mechanisms that could be used to speed deployment of promising technologies.

Application of One Health to National Goals

One Health (OH) recognizes the interconnectedness of human, animal, and environmental health and the impacts of health-related decisions made for one sector on the other sectors. Over the last 5 years, the OH approach has been cited in the *National Biodefense Strategy and Implementation Plan and the National Global Health Security Strategy*. Given the breadth of arenas in which OH is relevant and the potential need for a Federal coordinating body, OSTP asked STPI to examine how the OH approach could help achieve national goals across the social, economic, and environmental aspects of sustainable development and explore the functions a whole-of-government coordination mechanism might serve, such as supporting the integration of data from disparate fields. STPI derived an OH analysis framework from the Federal definition of One Health and the national OH strategies, identified 11 criteria, and assessed 51 national strategies, 3 for each of the 17 United Nations Sustainable Development goals. From this qualitative analysis, STPI established an OH integration score that reflected the degree to which OH was incorporated into each strategy, and analyzed which OH principles were most and least frequently cited in the reviewed strategies.

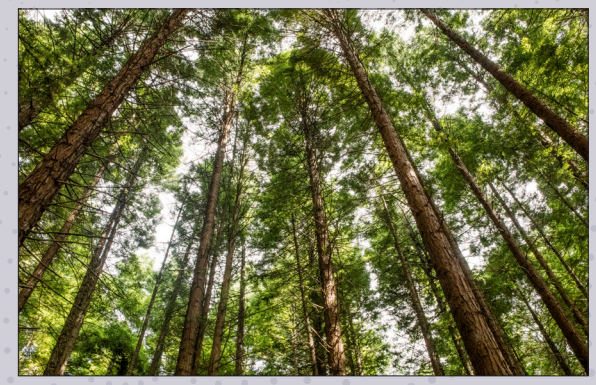
Metrics to Assess the Disaster Resilience of Health Systems

Climate resilience refers to how well infrastructure and associated systems withstand and how quickly they recover from natural hazards made worse by climate change (e.g., floods, hurricanes, heatwaves, and wildfires). Ensuring that health infrastructure, workforce, and data are climate resilient is critical to reducing the direct loss of lives and property as well as minimizing the indirect costs of disruption. Federal agencies have been directed in EO 14008 *(Executive Order on Tackling the Climate Crisis at Home and Abroad)* to develop climate adaptation and resilience plans that evaluate the most significant climate-related risks and vulnerabilities for agency operations and missions and to identify actions to manage those risks and vulnerabilities. OSTP asked STPI to support development of a framework for identifying relevant infrastructure, information, and human resource needs in order to strengthen health systems' overall climate resilience. The framework is intended to (1) characterize programs and associated requirements that Federal agencies and industries with missions relevant to climate resilience offer to stakeholders, (2) assess the current state of tools and services available for and relevant to implementation within existing national health systems, and (3) identify next steps to advance understanding of health community use of Federal programs and resilience tools. The framework will help coordinate screening mechanisms that can identify and organize existing and to-be-developed information and metrics relevant to health systems, as well as identify areas with sufficient or inadequate climate resilience.

Benefit-Cost Analyses for Ecosystem Services and Non-Fatal Health Effects

STPI was asked by OSTP to support the NSTC Subcommittee on Frontiers of Benefit-Cost Analysis as they developed a follow-up to a 2023 report entitled *Advancing the Frontiers of Benefit-Cost Analysis: Federal Priorities and Directions for Future Research*. STPI support focused on three areas: benefit-cost analysis for ecosystem services, non-fatal health effects, and public benefit programs. STPI conducted three separate literature reviews on these three areas. The literature reviews were an input to three workshops organized by the subcommittee and the workshops were themselves used to prepare the 2024 report.

ENVIRONMENT



Assessing Decarbonization Pathways for Selected Countries

The State Department's Office of the Special Presidential Envoy for Climate (SPEC) is charged with leading U.S. diplomacy to address the climate crisis. A priority for SPEC is to encourage other countries to put forth maximally ambitious 2035 Nationally Determined Contributions (NDCs) that align with the outcome of the first Global Stocktake, which determined that emissions reductions are not yet on track to meet the goals of the 2016 Paris Agreement. OSTP asked STPI to support SPEC by providing reviews and analyses of key countries of interest—Mexico, China, Brazil, Indonesia, Japan, South Korea, and Colombia—with significant opportunities for reducing their net greenhouse gas emissions. For each country, STPI's analyses compiled background information, historical emissions profiles, and NDC filings, and also reviewed official strategy documents and emission models. In addition, STPI identified models and data sources used to evaluate each country's NDCs and reviewed recommendations for alternative NDCs from civil society organizations. STPI's products were used by U.S. diplomats to prepare for bilateral discussions with each country and in preparation for the 2024 United Nations Climate Change Conference in Baku, Azerbaijan.

Identifying International Equities and Priorities Related to Climate-Induced Migration

The President issued EO 14013, *Rebuilding and Enhancing Programs to Resettle Refugees and Planning for the Impact of Climate Change on Migration,* which directed the National Security Advisor to prepare a *Report on the Impact of Climate Change on Migration* (released in October 2021). OSTP asked STPI to (1) review the literature to identify research gaps on climate-induced migration, (2) develop an inventory of the U.S. Government's efforts on climate and environment in equatorial and tropical countries, and (3) identify best practices for regional engagement on climate and the environment, including climate adaptation options. STPI's work is intended to help OSTP better understand the geopolitical forces behind climate-induced migration and assist with the development of strategies to better manage these impacts.

Identifying Research Equities and Priorities in Wildfire Science and Technology

Recommendation 110 from the congressionally mandated report *ON FIRE: The Report of the Wildland Fire Mitigation and Management Commission* suggests that a Federal coordinating body should be established to identify wildfire research gaps and science priorities. To identify known research needs and necessary participants, OSTP asked STPI to review eight reports published between 2014 and 2023 and identify the gaps and priorities related to research, data, and technology. In addition, OSTP asked STPI to identify Federal agencies, interagency coordination bodies, and non-Federal stakeholders with expertise and equity in wildland fire and wildfire science and technology. STPI identified seven cross-cutting priority areas for wildfire management and resilience: education and training; interagency and cross-sector coordination; practitioner-informed science and technology; data management; research leadership; information at appropriate scales; and diversity, equity, inclusion, and accessibility.

In addition, STPI identified 264 science and technology gaps and priorities across 6 focus areas: detection and modeling, firefighter operations and safety, land and fuels management, construction and zoning, public health and safety, and relief and recovery. STPI's report informed a June 2024 workshop on *Meeting Science & Technology Needs for Wildland Fire Risk & Resilience* held in Fort Collins, Colorado, and hosted by the Wildland Fire Leadership Council in collaboration with the NSTC Science for Disaster Reduction Interagency Working Group. STPI presented this work in a poster at the 2024 Annual Natural Hazards Research and Applications Workshop and published the findings in the report *Gaps, Priorities and Entities with Equities in Wildland Fire Science and Technology*.

Examining Nature-Based Solutions for Disaster-Resilient Infrastructure

Natural infrastructure, such as wetlands or forests, can complement or substitute for built infrastructure to provide more affordable and effective climate resilience. To realize this potential, decision-makers need to better understand the performance of nature-based solutions (NBS), a priority identified in the White House's 2023 *National Climate Resilience Framework* and the 2022 *Nature-Based Solutions Roadmap*. OSTP asked STPI to assess the strength of the evidence for NBS for disaster-resilient infrastructure and other benefit areas and to identify promising approaches to expand the use of NBS. To support OSTP, STPI conducted a rapid assessment of the effectiveness of various NBS for hazard risk reduction, water quality and quantity, carbon sequestration, and other co-benefits; supported a June workshop on *Science-Based Approach to Nature-Based Solutions for Hazard Risk Reduction*; evaluated common claims regarding the utility of NBS; and hosted a town hall at the American Geophysical Union in December 2024 on *Nature-Based Solutions in Climate Resilient Infrastructure: Evidence and Opportunities*.

National Planning for Civil Earth Observations

Earth observation systems provide crucial information on Earth processes, including data on land use/land cover, wildland fires, coastal zone management, precipitation, and many related regions and fields of science. A robust infrastructure of these observations is necessary to inform policy and decisions on a number of critical topics, including climate, environmental and human health impacts, and extreme weather predictions. Clear Federal coordination is needed to ensure efficient use of resources and adequate coverage of observation variables for current and future needs. In October 2010, Congress charged OSTP to produce and routinely update the national plan for civil Earth observations, a responsibility that is carried out by the U.S. Group on Earth Observations (USGEO). OSTP and USGEO engaged STPI to support the writing of the next national plan, which involved facilitating the dispositioning of interagency edits and comments and, separately, public comments made on a draft released in FY23. Additionally, STPI adjudicated subsequent subcommittee co-chair edits and comments, EOP edits and comments, and White House counsel edits and comments.

Earth Observation Assessment

The 2010 National Aeronautics and Space Administration Authorization Act instructed the Director of OSTP to establish a mechanism to ensure greater coordination of civilian Earth observations. In response, OSTP established the Earth Observation Assessment (EOA) to provide a government-wide evaluation of the Nation's Earth observation portfolio. The principal purpose of the EOA activity is to guide the development of the related National Plan for Civil Earth Observations and to "help coordinate federally supported Earth observations and investments, identify opportunities to advance Earth observations, and achieve national Earth observation policy objectives." OSTP and USGEO—a Subcommittee under the NSTC Committee on the Environment—engaged STPI to support its focused assessment of Earth observing systems, completed in late 2024. The STPI Earth observations elicitation team completed a collection of information on ~240 key Earth observing products and services related to climate. STPI also supported the drafting of the respective Societal Benefit Area Reports and Annexes for Agriculture & Forestry and Climate, as well as the EOA Methodology Report.

Cataloging Federal Climate Services

In response to EO 14008 on *Tackling the Climate Crisis at Home and Abroad,* NSTC stood up an FTAC to advance the development of an operational framework for Federal climate services. In 2023, the FTAC on Climate Services shared its findings in *A Federal Framework and Action Plan for Climate Services*, which included standing up an NSTC Subcommittee on Climate Services to coordinate the Federal climate services enterprise. OSTP asked STPI to develop an initial framework to catalog Federal climate services programs and provide technical and analytical support to compile the initial climate services catalog. STPI developed an outreach strategy to connect with relevant agencies and a data call to survey Federal climate services programs. This first phase of the catalog is intended to identify opportunities for improved Federal climate services coordination and delivery.

Support for Federal Groundwater Policy

PCAST established a Groundwater Working Group to better understand and make recommendations for management of groundwater resources in the United States. OSTP requested that STPI prepare background documents on the science and policy of groundwater and Federal agency equities with respect to groundwater quantity and quality. STPI also facilitated a 1-day hybrid workshop bringing together members of PCAST and representatives of various stakeholder communities, including farmers, academics, municipal managers, and Native American Tribes. STPI facilitated online and in-person discussions addressing community engagement and empowerment, science data gaps and opportunities, and water governance and incentives. STPI prepared a summary of the discussions that has informed PCAST's recommendations.

EMERGING TECHNOLOGIES AND TECHNOLOGY TRANSFER

AI Research Capacity

The CHIPS and Science Act includes a provision calling for NSF to conduct or support a study on AI research capacity at institutions of higher education in the United States. NSF contracted with STPI to perform this study. Key topics this study addressed include identifying which universities produce significant peer-reviewed AI research; determining which factors enable AI research at each of these institutions; identifying promising practices at these universities for broadening participation in AI research; and documenting the geographic diversity of universities with similar enabling factors and identifying how other universities could implement these enabling factors. For this study, STPI performed bibliometric analysis along with a literature review, interviews with institutional leaders and researchers, and analysis of publicly available data on institutional resources, faculty, student enrollment, and research funding.

Supporting the National Artificial Intelligence Research Resource

The National AI Initiative Act of 2020 called for NSF, in coordination with OSTP, to form a National AI Research Resource (NAIRR) Task Force to investigate the feasibility and advisability of establishing and sustaining a NAIRR, which would serve as a national means to democratize access to the resources and tools that fuel AI R&D. Following release of the report, an Interagency Working Group was formed and NSF asked STPI to assist in assessing the key capabilities provided by available technical and research resources and in identifying how these resources could combine to address key NAIRR goals. NSF announced the NAIRR pilot on January 24, 2024, as directed in EO 14110 on the *Safe, Secure, and Trustworthy Development and Use of Artificial Intelligence*. As part of the NAIRR Pilot effort, NSF deployed a request for information to solicit input from potential users of the NAIRR, which the STPI team analyzed and briefed in July 2024; a corresponding report was delivered in October 2024.

Interagency Coordination Models for Hazards Science and Technology

The Wildland Fire Leadership Council hosted a workshop on *Meeting Science & Technology Needs for Wildland Fire Risk & Resilience* in coordination with the NSTC Science for Disaster Reduction Interagency Working Group in 2024. One of the workshop goals was to recommend near- and long-term strategies and actions to improve interagency coordination around transferring research to operations. OSTP asked STPI to review existing interagency coordination frameworks and models across other, non-wildfire hazards to identify their governance, integration of science and technology throughout the decision-making process, authorities and guiding documents, and role of Federal and non-Federal agencies. Identifying the structure, best practices, and challenges from existing interagency coordination systems for other types of hazards may inform future efforts for coordinating wildfire science, data, and technology.

Assessing the Need for a U.S. Artificial Intelligence Scholarship for Service

The CHIPS and Science Act of 2022 required the Director of NSF, in coordination with the Office of Personnel Management (OPM), to create a report on the need for and feasibility of establishing a Scholarship for Service (SFS) program to recruit and train the next generation of AI professionals to meet the needs of Federal, State, local, and Tribal governments. NSF asked STPI to conduct research and analyses in three areas to inform the development of the NSF report, including recent statistical data on the size, composition, and educational requirements of the Federal AI workforce; the capacity of institutions of higher education to produce graduates with degrees, certifications, and relevant skills related to AI; and the need for establishing an AI SFS program similar to the existing NSF CyberCorps® SFS program. In FY24, STPI conducted research and analyses and prepared reports on each of these three areas of interest. These reports served as inputs to NSF's report to Congress, whose development STPI researchers supported and which was delivered in May 2024. STPI also supported OPM in analyzing data from its Job Analysis survey to inform development of an OPM competency model for AI.

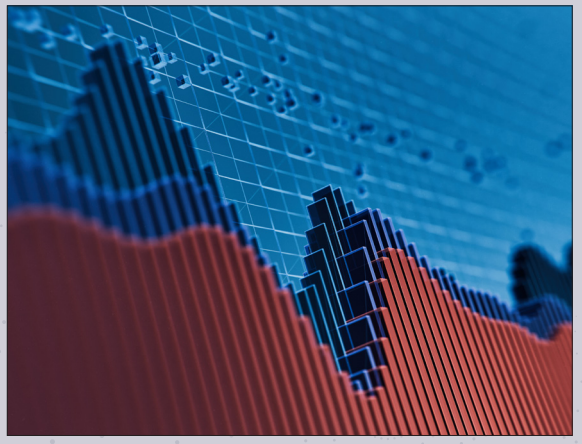
Quantum Networking Infrastructure and Investments

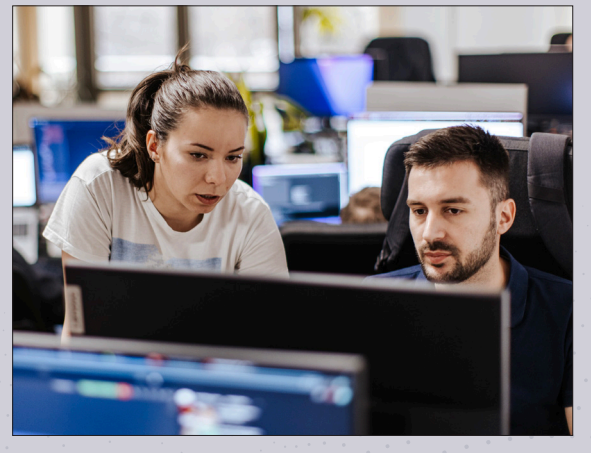
The National Quantum Initiative (NQI) Program was established in 2018 with the passage of the National Quantum Initiative Act (NQIA) to "ensure continued leadership of the United States in quantum information science and its technology applications." Among its provisions, the NQIA (as amended) formally established the National Quantum Coordination Office (NQCO) within OSTP; the National Quantum Initiative Advisory Committee (NQIAC), a Federal Advisory Committee charged with advising the President on the NQI; and the Subcommittee on Quantum Information Science and the Subcommittee on the Economic and Security Implications of Quantum Science of the NSTC.

STPI was asked to provide technical assistance to the NQIAC and its subcommittees in their work to develop recommendations for a report on quantum networking. STPI researchers provided information on major U.S. quantum networking (QN) infrastructure and investments, and supported development of the NQIAC report on *Quantum Networking: Findings and Recommendations for Growing American Leadership*, released on September 6, 2024.

In addition, the NQCO requested that STPI conduct research and analyses on the global landscape in QN R&D to help inform interagency efforts to develop a new strategy document on advancing U.S. leadership in QN, as called for in the CHIPS and Science Act. STPI researchers reviewed existing literature and data sets on different nations' policies and performance related to quantum information science and QN R&D, characterized QN research outputs and collaborations by researcher country of affiliation over time using bibliometrics and machine learning-based topic modeling, and cataloged major infrastructural initiatives for QN testbeds, prototypes, or demonstrations around the world. STPI researchers delivered a report with their findings to the NQCO on September 20, 2024.

AGENCY PROGRAM DEVELOPMENT AND PORTFOLIO EVALUATIONS





Evaluating the Adolescent HIV Prevention and Treatment Implementation Science Alliance

The Adolescent HIV Prevention and Treatment Implementation Science Alliance (AHISA) was established by the Fogarty International Center (FIC) of the National Institutes of Health (NIH) in 2017 to create a platform for bidirectional learning between researchers and implementers (e.g., local clinicians, in-country program implementers, health policymakers) in sub-Saharan Africa. In December 2022, FIC asked STPI to conduct an evaluation of AHISA, assessing its outcomes and impacts and the strengths and weaknesses of the model. In 2023, STPI staff collected primary data from AHISA participants through virtual interviews, reviewed program documentation, and identified and analyzed AHISA-related publications. Reporting to FIC is ongoing; FIC is expected to use the information to guide future decision-making regarding AHISA's future.

Strategic Planning Support for NSF Science and Technology Centers

Science and Technology Centers (STCs) are one of NSF's flagship initiatives to support innovative, complex, and potentially transformative research and education projects that require large-scale, long-term awards. NSF asked STPI to conduct an external evaluation of the STCs funded between 2005 and 2016 to address the following questions: Have the STCs conducted transformative research, contributed to the training of a diverse STEM workforce, and enabled dissemination, transfer, and application of knowledge to benefit science and society? What are the main legacies of the STCs? What changes to the STC program are warranted? In the past year, STPI completed interviews with STC directors and external experts, analyzed numerous administrative documents and data, and fielded a survey of participants. STPI gave multiple presentations to share progress with NSF and will prepare a report summarizing the accomplishments of STCs and making recommendations to help NSF manage the program in the future.

Evaluating the NIH Director's Transformative Research Award's Anonymized Review Process

The NIH Director's Transformative Research Award initiative is a component of the NIH Common Fund's High-Risk, High-Reward Research program, which supports exceptionally creative, highly innovative scientists carrying out research with the potential for broad impact in biomedical or behavioral science. Beginning in FY21, NIH piloted a 3-year anonymized review process of the Transformative Research Award applications to determine whether an anonymized review process could be conducted and would meet the NIH merit review criteria. Additionally, NIH asked STPI to determine whether an anonymized review process would change the demographic and institutional diversity of the applicant and awardee groups. For FY21–23, STPI performed annual surveys of the applicants and reviewers, examined changes in applicant and awardee diversity, and prepared annual comprehensive evaluative reports. In FY23–24 STPI analyzed the FY21–23 cohort in aggregate and prepared a comprehensive

final report. STPI found that the anonymized review process met NIH review criteria for rigorous review and shifted the diversity characteristics of the anonymized review applicants. The results of STPI's evaluation will be used in the NIH Director's policy decisions for the Transformative Research Award Initiative, as well as possible expansion to other initiatives and mechanisms.

Evaluation, Strategic Planning, and Other Analytical Support for the National Institute on Aging

STPI is providing evaluation support to the Office for Planning, Analysis, and Evaluation at the National Institute on Aging (NIA). In the past year, STPI completed two projects: (1) an evaluation of NIA's Chartered Committees (CC) that review career development applications; and (2) stakeholder engagement for the development of the NIA Strategic Plan for Workforce and Research Engagement. For the evaluation of CC, STPI conducted interviews with extramural reviewers; analyzed data from interviews with these reviewers as well as program officers and scientific review officers (these interviews were conducted by NIA); analyzed scoring and other administrative data; and developed a PowerPoint presentation summarizing findings and making recommendations to NIA for how to improve CC. For the Strategic Plan, STPI facilitated 12 focus groups and 3 listening sessions with NIA staff (176 participants in total) on the topics of workplace climate, internal workforce, external workforce, and health research. STPI developed a report based on the information collected in these sessions. This information is being used by NIA to inform the Strategic Plan.

Clinical Trials and Translational Research Advisory Committee Strategic Planning

In November 2019, the National Cancer Institute (NCI) convened a Strategic Planning Working Group to develop recommendations for realizing its vision for cancer clinical trials and improving the operational efficiency and reducing the cost of cancer clinical trials today and in the future. STPI provided strategic and analytical support for the working group, including drafting its 2020 report. Since that time, STPI has continued to assist NCI with implementation of the report's recommendations by facilitating an advisory group's deliberations on reducing data collection burden and promoting the integration of clinical trial activities with electronic medical record systems, including drafting a final report. In FY24, STPI also advised NCI on strategic approaches for implementing several other working group recommendations and facilitated discussions with NCI staff and extramural stakeholders concerning those approaches.

Implementation of Recommendations by the National Cancer Institute Clinical Trials and Translational Research Advisory Committee Clinical Trials Informatics Working Group

STPI provided analyses and strategic guidance for implementing the recommendations of the NCI Clinical Trials Informatics Working Group (CTIWG) established by the NCI Clinical Trials and Translational Research Advisory Committee (CTAC) in 2015. The CTIWG's purpose was to provide advice on NCI's Clinical Trials Reporting Program (CTRP) and increasing the usability and accessibility of CTRP clinical trial information. In FY24, STPI provided strategic and analytical support for NCI's development and deployment of a reporting tool designed to provide NCI Designated Cancer Centers with access to a subset of CTRP clinical trial information. This included analysis of feedback from Cancer Centers on both virtual demonstrations and initial deployment of the tool.

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