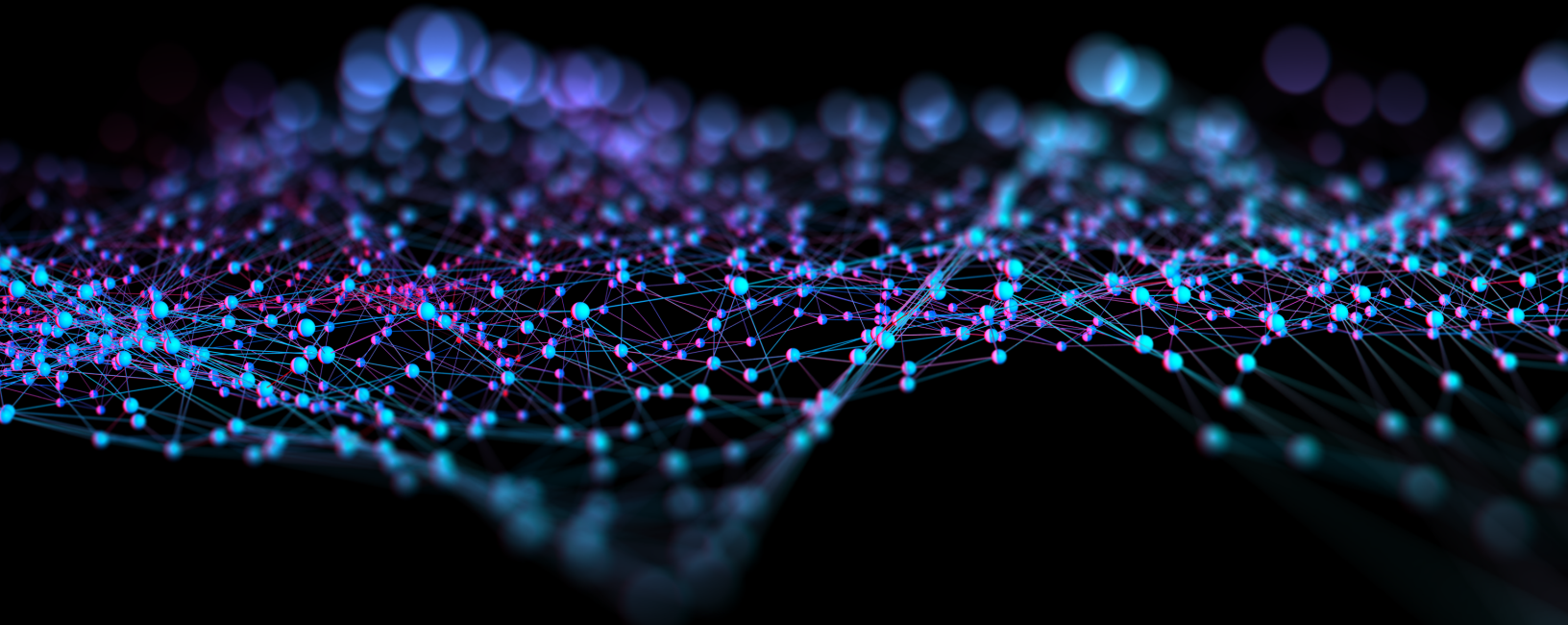


IDA

SCIENCE AND
TECHNOLOGY
POLICY INSTITUTE

REPORT TO THE PRESIDENT FISCAL YEAR 2018



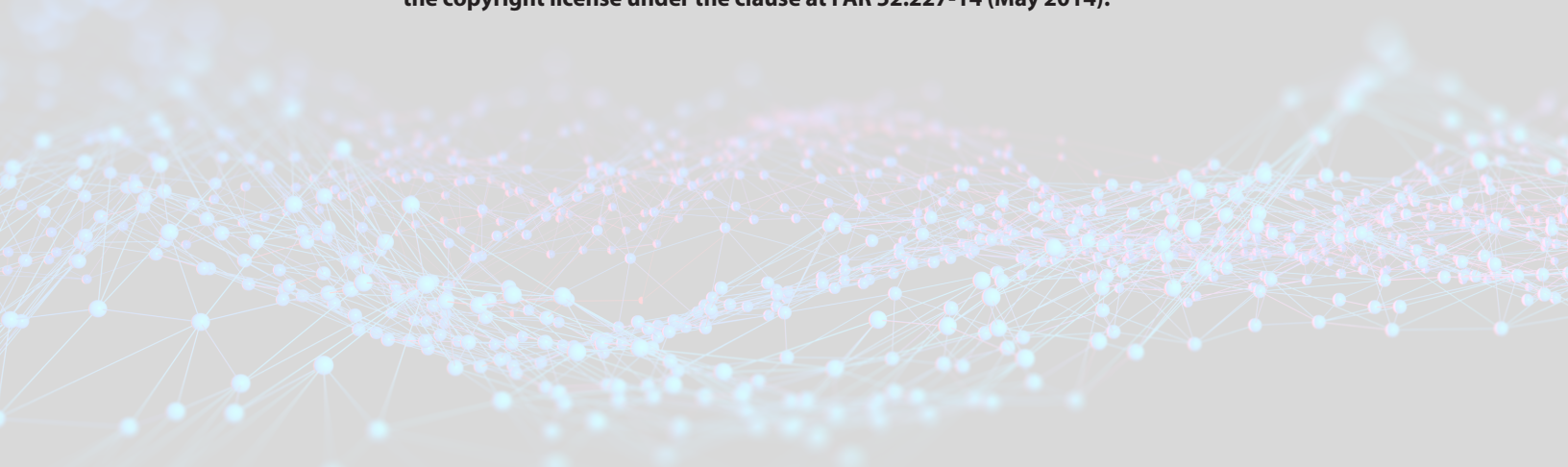


The Institute for Defense Analyses is a nonprofit corporation that operates three Federally Funded Research and Development Centers. Its mission is to answer the most challenging U.S. security and science policy questions with objective analysis, leveraging extraordinary scientific, technical, and analytic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

Copyright Notice

© 2019 Institute for Defense Analyses, 4850 Mark Center Drive, Alexandria, Virginia 22311-1882 • (703) 845-2000.

This material may be reproduced by or for the U.S. Government pursuant to the copyright license under the clause at FAR 52.227-14 (May 2014).



LETTER FROM THE DIRECTOR OF STPI

Dear Mr. President:

It is a pleasure to present to you our report of activities at the IDA Science and Technology Policy Institute (STPI) for fiscal year 2018. This overview is delivered in accordance with our congressionally mandated roles and responsibilities as a federally funded research and development center, primarily in support of the White House Office of Science and Technology Policy, under the sponsorship of the National Science Foundation.

Our institute was established by Congress in 1991, and we are directed by statute to report on significant trends and developments in science and technology in the United States and abroad; analyze those trends with attention to the Federal science and technology portfolio; and perform studies that will ensure the long-term strength of American science and technology. Associated with those goals is an abiding interest in keeping America at the forefront of scientific discovery, and ensuring that American scientists and engineers can lead the world in innovation and technical progress.

In keeping with its mission, STPI's analyses this past year ranged in subject focus from informatics and 5G networks, to innovation policy and STEM education, to space, aeronautics, and critical infrastructure. As in previous years, some of STPI's analyses supported other executive branch agencies, including the National Science Foundation, the National Aeronautics and Space Administration, the National Institutes of Health, the Department of Commerce, the Department of Energy, the Department of Homeland Security, and the Department of Transportation.

On behalf of my colleagues, I thank you for the opportunity to serve our government and our Nation through the application of scientific knowledge.



Mark J. Lewis



INTRODUCING THE IDA 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) 1991 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.

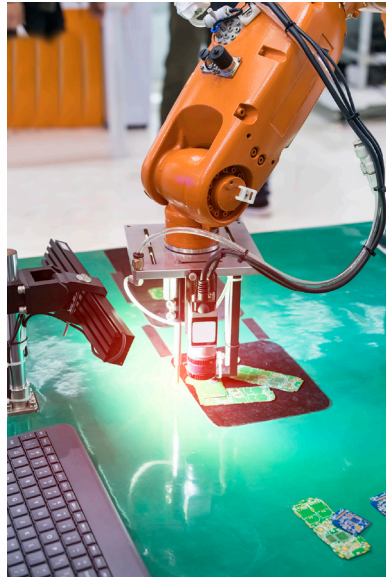
Consistent with congressional direction, STPI provides analyses of significant science and technology policies and developments in the United States and abroad for OSTP, its primary sponsor, and for other Federal Government organizations with science and technology responsibilities. To ensure the continued 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

Analyzing Federal Science and Technology Issues	2
Science and Technology Developments	3
Infrastructure Assessments	9
Economic Analyses	11
Reviewing Federal Programs and Portfolios	14
Government Practices	15
Biomedical Research	17
Portfolio Evaluations	19
Providing Technical and Analytic Support	22
National Strategies, Roadmaps, Action Plans, and Initiatives	23
National Science and Technology Council Support	25

ANALYZING FEDERAL SCIENCE AND TECHNOLOGY ISSUES



SCIENCE AND TECHNOLOGY DEVELOPMENTS

Global trends in space situational awareness and space traffic management

Space systems play an ever-increasing role in terrestrial applications—from GPS to meteorology, telecommunications, and national defense. If current satellite launch plans are realized, 60 countries will have launched approximately 4,700 commercial, civilian, and military satellites into space by 2026. STPI assessed practices for space situational awareness (SSA)—the tracking of objects in Earth orbit—and space traffic management (STM)—the oversight, coordination, regulation, and support of space activities—to understand current and emerging trends in SSA privately and globally. STPI then developed likely scenarios for SSA and STM that reflect this increase in the number of active satellites and the potential for increased space debris and collisions. STPI found that, in the next decade, the U.S. Government capabilities in SSA would continue to be seen as the global gold standard; however, many other countries would likely develop capabilities that would allow them to become increasingly more self-sufficient. STPI determined that these trends have significant implications for transparency in space activities and that the increasing global competence in SSA likely means more participants in STM discussions. The findings will inform SSA and STM budget decisions.

Mars Roadmap 2033

In response to the NASA Transition Authorization Act of 2017, NASA developed a human spaceflight roadmap to expand human presence beyond low-Earth orbit to the surface of Mars. NASA asked STPI to (1) assess the technical development, test, fielding, and operations plan to successfully launch a Mars human space flight mission by 2033; (2) review the annual budget profile, including cost estimates, for this mission plan; and (3) compare the annual mission budget profile to the 5-year budget profile contained in the President’s Budget Request for FY 2017. Using NASA’s current and notional plans for human exploration as the basis for this assessment, STPI drew on information from publicly available government documents, internal NASA documents, and peer-reviewed scientific literature; and interviewed individuals from NASA and the commercial space industry. STPI found that NASA will achieve many of the Mars Roadmap goals but that a mission to Mars orbit by 2033 is not likely.

Commercial space, nuclear power, and propulsion

The use of space nuclear power is an important component of U.S. goals for deep space missions, especially those outside the main asteroid belt. In 2017, STPI examined a potential process for fission power and propulsion systems and reviewed the space nuclear launch approval process for radioisotope power systems. As part of this evaluation, STPI concluded that there is virtually no legal guidance for private companies wishing to provide or use space nuclear systems. In FY 2018, OSTP asked STPI to examine commercial interest in the development and use of radioisotope and fission technologies for power or propulsion, including barriers to commercial activity. STPI also assessed pertinent legal and regulatory documents that would guide commercial use of space nuclear power and developed a hypothetical launch approval process that would spur commercial activity while maintaining rigorous standards for safety. The report will inform policy considerations related to space nuclear power.

Power requirements for deep space missions

Deep space missions require electric power that ranges from hundreds to thousands of watts for propulsion systems and, depending on the mission, for instrumentation such as onboard sensors, tele-operated rovers, remote science packages, and communication relay stations. Human space flight to planetary surfaces and outer planets will require even more power. OSTP asked STPI to assess the power requirements for a range of space science and human space exploration missions and to identify strengths, limitations, and current state of the art of each power source. STPI reviewed historical and current technology reports and conducted a series of expert interviews with NASA, the Department of Energy, the Department of Defense, and other space organizations. STPI determined that sources of power based on radioisotope and nuclear fission are the most suited for missions that require high power levels or are far away from the Sun. The report also identified obstacles that limit NASA's ability to adequately use nuclear power in space. Subsequently, STPI examined the challenges related to the space nuclear launch approval process, assisted a National Science and Technology Council (NSTC) interagency working group in developing recommendations that led to an updated space nuclear launch policy, and evaluated commercial space nuclear efforts and launch approval processes.

On-orbit servicing, assembly, and manufacturing

The recent successful demonstration of additive manufacturing on the International Space Station, as well as advances in key enabling technologies such as robotics and automation, offer the opportunity for on-orbit manufacturing and assembly of spacecraft and components; however, important questions about basic material properties, repeatability, and reliability are not yet answered. OSTP asked STPI to assess the potential benefits and costs of on-orbit manufacturing and assembly of spacecraft for a range of mission applications; to identify the strengths, limitations, current state of the art, and policy challenges; and to recommend ways to advance the science and

technology necessary for on-orbit manufacturing and assembly. STPI reviewed the technical literature, interviewed Federal and private sector leaders about on-orbit manufacturing and assembly, and developed cost-benefit models for space-based additive manufacturing and product assembly. Following delivery of its report to OSTP, STPI organized an OSTP-led roundtable meeting to discuss related issues. The STPI-hosted roundtable, which included government and industry representatives, addressed the progress, challenges, and priorities for on-orbit servicing, assembly, and manufacturing technology development for spacecraft and the related policy implications.

Near-Earth objects partnerships and capabilities database

Small asteroids and other near-Earth objects (NEOs) entering the Earth's atmosphere are potentially hazardous. The NASA Planetary Defense Coordination Office (PDCO) is responsible for finding, tracking, and characterizing NEOs. The PDCO asked STPI to identify current NASA partners, new organizations with whom PDCO might partner, and the technical capabilities of each organization. To this end, STPI drafted the NASA Planetary Defense Coordination Office Near-Earth Objects Observations Partnerships Request for Information (RFI) to solicit capability statements and identify private sector and philanthropic organizations that could contribute to the NEO Observations Program. These capabilities might include telescopes with appropriate aperture diameters, infrared sensors, long-range radars with power and resolution, satellite technical information, or ground station information. STPI analyzed the RFI data and integrated the results with the existing PDCO partnership information. NASA used this information as the basis for a report to Congress that describes how best to expand collaborative partnerships to detect, track, catalogue, and categorize NEOs, as requested in Section 512 of the NASA Transition Authorization Act of 2017.

Earth observations

Earth observation systems, sensors, and networks provide measurements of the Earth and its processes that are critical to decisions that protect lives, property, and critical infrastructure, and enhance national security. These measurements include observations of weather, land use and change, elevation, water level and flow, oceans, natural resources and ecosystems, as well as reference measurements that enable precision location and timing services.

OSTP asked STPI to develop a framework for the 2nd National Plan For Civil Earth Observations for the U.S. Group on Earth Observations (USGEO) Subcommittee of the NSTC that includes principles that will guide coordinated Federal agency Earth observation activities, operations, and research, and a National strategy for Earth Observations policy.

STPI conducted an analysis of the Civil Applications Committee (CAC), managed by the United States Geological Survey, which coordinates civil agency acquisition and use of classified satellite information collected by the Department of Defense (DOD) and the United States Intelligence Community (IC) for civil, scientific, and environmental purposes.

STPI presented to OSTP its findings on ways to improve CAC and complementary interagency processes to better accommodate information flow and the efficient coordination of civil agency needs for DOD, the IC, and commercial geospatial observations.

Arctic observing assessment framework

At OSTP's request, STPI continued work in FY 2018 on Arctic observations, specifically sea ice forecasting, with the United States Arctic Observing Network. This effort is based on the International Arctic Observing Assessment Framework that was developed through the Arctic Council's Sustaining Arctic Observing Networks initiative. STPI built upon an existing Earth Observation Analysis conducted in 2016 on behalf of OSTP and the USGEO subcommittee, to map the space-based, airborne, terrestrial, and marine remote and in situ observations that are used in major U.S. sea ice models and forecasts. In 2018, STPI presented the results of this work internationally at the Arctic Observing Summit, the Arctic Science Summit, and the second Arctic Science Ministerial.

Logistical support for Antarctic research

The National Science Foundation (NSF) asked STPI to develop a data collection instrument that would assist it in evaluating the effectiveness of the NSF contract on logistical support for the United States Antarctic scientific research program. Following an extensive series of interviews with NSF program staff, contract staff, and research community members, as well as site visits to contract supply warehouses and research

stations, STPI identified a set of data elements that assesses the delivery of logistical support for planned and unanticipated research and personnel needs, as well as specific contractor support functions. In FY 2018, STPI continued its annual task to collect and analyze the survey responses and presented the results to the sponsor. NSF is using the STPI findings to improve logistics support services and NSF's effectiveness in supporting the Antarctic research projects.

Artificial intelligence

The United States has led the world in artificial intelligence (AI) research and development through a successful combination of public and private investments. OSTP asked STPI for several in-depth analyses that assess the elements of current U.S. AI research, development, testing and evaluation (RDT&E) and, using a historical narrative for technological advances, assess the likely impact of AI—especially automation and robotics—on the U.S. workforce. Through a series of analyses, STPI determined that U.S. dominance in AI RDT&E is founded on strategic funding of AI initiatives, strong private sector investments, and a talented and diverse workforce. The U.S. can maintain its AI leadership through continued investments in long-range, fundamental research efforts, policies that incentivize the acquisition and retention of the diverse AI talent pool, and policies that incentivize private sector investment. Finally, STPI's review of the literature found that AI is likely to change the nature of the work being performed across the job skills spectrum, particularly for those jobs that require the collection and processing of data or physical activities that are routine and predictable.

Critical minerals

Critical minerals are defined by the Department of the Interior as non-fuel minerals or mineral materials that serve an essential function in the manufacture of a product and have a supply chain vulnerable to disruption. In December 2017, Executive Order 13817 requested an assessment of (1) technologies for recycling and reuse of critical minerals; (2) investment and trade barriers to access and process critical minerals; (3) accessibility of geological and geophysical data; and (4) regulations that hinder domestic mining production. The Department of Commerce (DOC), OSTP, and the NSTC Subcommittee on Critical and Strategic Minerals Supply Chains asked STPI to provide technical review and synthesis for the overall report, assist in the development of the national strategy chapter, and identify release options and requirements for the final report. To achieve these aims, STPI convened interagency discussions, adjudicated interagency feedback, provided recommendations and technical support, and drafted text for the report. The strategy was delivered to the Executive Office of the President in mid-November 2018.

Air Force S&T initiative

In September 2017, the Secretary of the Air Force launched an initiative to maintain the U.S. science and technology (S&T) advantage in air defense of the Nation. This effort is called the *Science and Technology 2030 Initiative*; its goal is the development of a

strategy that will guide United States Air Force (USAF) S&T through 2030. In March 2018, the Air Force Research Laboratory asked STPI to facilitate eight expert panels that would evaluate the S&T needed by the USAF to accomplish its mission in 2030 and beyond. STPI hosted panels on cyber resilience, data analytics, space systems, materials science, spectrum, weapons and defense, human performance, and future discoveries and provided summaries for each meeting. STPI also facilitated the integration of the findings from the eight panels into overarching USAF S&T research needs. These efforts directly contributed to the *Air Force S&T 2030 Strategy*.

INFRASTRUCTURE ASSESSMENTS

Resilient buildings

Buildings and infrastructure systems function as interdependent systems that provide services to a community. During and after a hazard event, the damage to building systems and their potential degradation and failure could dramatically alter a community's recovery from a disaster. The report of the U.S. Senate Committee on Appropriations for FY 2017 mandated that the National Institute of Standards and Technology (NIST) develop a comprehensive report on the development and implementation of an immediate occupancy performance objective that would enable residential and commercial buildings to function during and after a hazard event, and enable rapid recovery. The NIST Immediate Occupancy Report, *Research Needs to Support Immediate Occupancy Building Performance Objective Following Natural Hazard Events*, was published in August 2018 and submitted to Congress. The report was co-authored by NIST and STPI researchers and marks the culmination of nearly a year of collaboration between the National Earthquake Hazards Reduction Program (NEHRP), NIST's Community Resilience Group, and STPI. The research and implementation actions outlined in the report collectively describe steps needed to achieve what NEHRP's Director stated could be the "biggest change in building standards and codes in 50 years."

Critical Infrastructure

Critical infrastructure is a backbone for economic prosperity and an important component of national security. The Department of Homeland Security (DHS), in coordination with OSTP and other Federal departments and agencies, asked STPI to provide research and analysis on the security and resilience of the critical national infrastructure, primarily for energy and communication systems. STPI assisted the NSTC Critical Infrastructure Resilience and Security (CISR) Subcommittee in convening the 2018 CISR Stakeholder Workshop in which Federal, State, private, and academic stakeholders shared research needs, breakthroughs, and observations about emerging threats and challenges to the security and resilience of the Nation's critical infrastructure. In May 2018, at the request of the DHS National Protection and Programs Directorate, STPI conducted the first annual CISR research and development (R&D) metrics data collection to meet national policy requirements and track the progress and effect of CISR R&D activities described in the CISR Implementation Roadmap. STPI developed the Maturity Scale Framework (MSF) to meet the PPD 21 requirement for annual CISR performance metrics. In FY 2018, STPI assessed CISR R&D progress against the MSF and evaluated whether the MSF is an appropriate tool to track and assess the impact of CISR R&D activities on the Nation's overall security and resilience. STPI concluded that the MSF is able to monitor CISR progress and identified several opportunities to increase the utility of the metrics for use by agencies and the Subcommittee.

Continuity of government operations during a national emergency

The Director of OSTP is responsible for communications-related National Security and Emergency Preparedness (NSEP) under Executive Order 13618 (Assignment of National Security and Emergency Preparedness Communications Functions) and Presidential Policy Directive 40 (National Continuity Policy). OSTP asked STPI to conduct analyses in support of OSTP's NSEP responsibilities and to provide continuity-related support for executive branch policy. In FY 2018, STPI provided a range of analyses associated with OSTP/Office of Management Budget Directive D-16-1, Minimum Requirements for Federal Executive Branch Continuity Communications Capabilities—a White House directive that sets executive branch requirements for continuity communications. The requirements set by this policy help to ensure that departments and agencies are able to communicate and accomplish their essential functions if they were required to evacuate Washington, D.C.

Advanced manufacturing workplace

Over the last decade, manufacturing practices have evolved to include automation and robotics, computation and computer-assisted processes, sensing and networking technologies, as well as new materials and capabilities. In FY 2016–17, STPI developed a definition of advanced manufacturing and a framework through which the National Institute for Occupational Safety and Health (NIOSH) might evaluate the occupational safety and health considerations in the advanced manufacturing workplace. The resulting report was published on the NIOSH website. In FY 2018, NIOSH asked STPI to examine the state of the art for additive manufacturing, biomanufacturing, and the digitalization of manufacturing. STPI developed papers on each topic, determining that digitalization of manufacturing is an enabling technology that can be applied across industrial sectors, whereas additive and biomanufacturing are specific categories within advanced manufacturing. STPI also created a novel biomanufacturing taxonomy that reflects the types of processes currently in use.

ECONOMIC ANALYSES

Civilian nuclear energy technology

In the United States, nuclear energy accounts for almost 20 percent of electricity generation and is important for maintaining electric grid reliability and price stability—all vital to the Nation’s economic health and security. The Federal Government has a unique role in supporting the development and deployment of new nuclear reactor technologies, and well-established roles in the licensing and certification of existing commercial reactor technologies. OSTP asked STPI to estimate potential revenues from sales of new Gen IV reactor concepts and small modular reactor technologies in the United States and the rest of the world and to assess how regulations and procedures of the Nuclear Regulatory Commission might affect their development. In FY 2018, STPI estimated the market for new reactor technologies nationally and globally.

STPI then analyzed the implications of government policies for the technological and economic development of the U.S. civilian nuclear power industry. STPI reviewed the history of the U.S. nuclear power industry and the role of the Federal Government in its development, and created an inventory of historical and current policies that support this ecosystem. This analysis highlighted the large role played by the Federal Government in supporting civilian nuclear power and informed OSTP’s consideration of future Federal Government funding for development of new reactor technologies.

Space economy

The space industry is a substantial, innovative component of the global and U.S. economy. OSTP asked STPI to define the scope of the global space economy, provide estimates of its size, and identify potential areas for U.S. Government activities. STPI defined the space economy as the value of goods and services provided to governments, households, and businesses from space or used to support activities in space. STPI then analyzed estimates of the space economy reported in the three most highly regarded data sources against this definition, ensuring the consistency of the data for comparison purposes. We found that government expenditures on space provide almost half of final demand for goods and services from space, final demand is growing at a nominal two percent per year, and government budgets will continue to play a large role in purchases of space industry products.

As part of its commitment to maintaining U.S. global leadership in space markets, OSTP also asked STPI to perform a foundational assessment of the U.S. space sector-related export control enterprise. Using a review of all major export control legislation for space technologies and interviews with officials in the intelligence community, in other stakeholder Federal agencies, and in private sector companies, STPI assessed the effect of these controls on the scientific, technical, and commercial development of U.S. space technologies and their impact on national security. This analysis was used by OSTP, the National Space Council (NSpC), and the Interagency Working Group on Space Export Controls to identify areas for policy change.

Additionally, OSTP and NSpC asked STPI to assess the utility of a government strategic investment fund to achieve the Space Policy Directive-1 goals of returning humans to the Moon and fostering private space markets. STPI reviewed reports, academic journal articles, and the public finance literature and interviewed over 60 representatives of investment funds, industry, and government agencies, as well as academics and other observers engaged with the space industry. STPI identified nine key challenges to achieving U.S. space policy goals and demonstrated that none aligned with the rationale for a government strategic investment fund. STPI found that economic policy mechanisms with minimal overhead, such as in-kind subsidies and “solutions-based” contracts, would better support OSTP and NSpC goals.

China’s commercial space sector

Many nations are seeking a competitive advantage in developing space assets by using public and private enterprises to obtain the necessary science and technology. In this context, STPI was asked to evaluate the landscape of China’s nascent but growing commercial space sector. Since 2014, private companies in China have been allowed to research, manufacture, launch, and operate commercial satellites. To assess current and future Chinese commercial capabilities in space, STPI developed a database of private or semi-private Chinese companies that produce goods and services for the space sector. STPI’s data collection activities included site visits; in-person interviews with key academic, government, and industry personnel; review of industry databases; and web-crawls of English and Chinese websites. From these data, STPI identified major product lines and assessed their technological sophistication, examined market structure and the availability of capital, and estimated the relative roles of private and state-owned firms in the domestic and global markets. STPI also identified key regulatory and other challenges facing private Chinese firms in the space sector.

REVIEWING FEDERAL PROGRAMS AND PORTFOLIOS



GOVERNMENT PRACTICES

Federal technology transfer

Improvement in the transfer of federally funded technologies from lab to market is a cross-agency priority (CAP) in the President's Management Agenda. OSTP and NIST are co-leading activities to streamline technology transfer under the NSTC Lab-to-Market Subcommittee. OSTP asked STPI to support the Subcommittee by collecting data related to existing and recently initiated Federal activities, analyzing the results, and mapping them to CAP objectives and the Administration's research and development (R&D) priorities. These data, plus STPI literature reviews and stakeholder interviews, provided baseline information to the five CAP objective strategy teams within the Subcommittee. STPI was then instrumental in helping the strategy teams develop their goals and objectives.

In a parallel activity, NIST asked STPI to provide technical and analytical support for its Return on Investment (ROI) Initiative, a stakeholder engagement activity to improve commercialization and Federal R&D technology transfer. STPI reviewed background reports on intramural and extramural technology transfer, qualitatively coded and analyzed the results of a NIST request for information and four public fora, and prepared a report describing the challenges and possible legislative, regulatory, and policy actions the Federal Government could take to improve technology transfer. The report (NIST Special Publication 1234, <https://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.1234.pdf>) has informed NIST deliberations for legislative revisions.

Management science applied to acquisition issues

The 2016 National Defense Authorization Act directed DOD to establish a set of science, technology, and innovation activities aimed at improving performance and reducing developmental and life cycle costs of DOD's Major Automated Information Systems. As part of the implementation of this legislation, DOD determined there was no substantive Federal laboratory involvement in advancing effective business acquisition. To assist DOD in responding to these congressional concerns, OSTP asked STPI to conduct background research and facilitate a workshop to explore the utility of research and development programs applying management science (a broad interdisciplinary field that combines mathematically oriented techniques such as modeling and simulation, game theory, and machine learning with decision and behavioral analysis) to DOD-specific acquisition management issues. STPI developed case studies highlighting examples of the effective use of management science in industry and government; described a set of research questions for management science experts to explore; and identified government data sets of interest to management science experts. This background research informed the format, agenda, and participants for the 2018 DOD workshop: Future Direction of Management Science for S&T Management. The workshop involved academic, private, and government sector participants who discussed research opportunities to analyze and build DOD capacity for management science.

Federal prize authority

The America Creating Opportunities to Meaningfully Promote Excellence in Technology, Education, and Science (COMPETES) Reauthorization Act of 2010 gives all agencies broad authority to conduct prize competitions in order to spur innovation, solve challenging problems, and advance their core missions. As of 2017, OSTP and the Federal science agencies are required to report their prize competitions biennially and to include crowdsourcing and citizen science activities conducted under the Crowdsourcing and Citizen Science Act. OSTP asked STPI for assistance in completing its congressionally mandated FY 2017–18 progress report. STPI developed a data collection tool for Federal agencies; conducted webinars to address the agency data call and reporting questions; and compiled and analyzed agency progress, multi-year trends for incentive prizes, and the use of crowdsourcing and citizen science. STPI selected incentive prizes and citizen science projects that could be highlighted in the report and summarized agency prizes and activities.

Foreign investment: CFIUS reviews

The Committee on Foreign Investment in the United States (CFIUS) is an interagency body that assists the President in overseeing the national security aspects of foreign direct investment in the U.S. economy. OSTP, a voting member of CFIUS, asked STPI to provide technical review of cases, strategic analyses, and process improvement recommendations in support of this role. STPI staff reviewed case materials and highlighted open questions or concerns presented by the proposed transaction. STPI assisted OSTP in developing and documenting a case review process, created a case tracker, and helped estimate resource requirements as the caseload increased under the new legislation. STPI's analyses have appeared repeatedly in case documentation and have been integral to case outcomes. Additionally, STPI reviewed current OSTP processes for onboarding and assigning subject matter experts to CFIUS cases, transmitting weekly case updates, and completing quick turnaround requests—and made recommendations for process improvements.

Automatic Identification System

The U.S. Coast Guard collects vessel data using a maritime navigational safety communications system called the Automatic Identification System (AIS). These data include the vessel's position, heading information, course, and speed over ground, and may also include the rate of turn; angle of heel, pitch, and roll; destination; or estimated time of arrival. Approximately 15 terabytes of AIS data are generated every year; however, real-time Nationwide AIS (NAIS) data are available only to certain approved users. Others must use static, derived products that have an associated latency or pay a third party for data access. For this project, OSTP asked STPI to examine the current state of AIS data provision and to identify ways to enhance the discoverability, accessibility, and usability of AIS data. STPI analyzed Federal agencies' use of and challenges associated with AIS data, their administrative processes and costs, and the utility of the data. STPI also generated options to increase the discoverability, accessibility, and usability of AIS data.

BIOMEDICAL RESEARCH

Cancer care delivery in a community setting

Following STPI's extensive, multi-year involvement in the development of the National Cancer Institute (NCI) Community Oncology Research Program (NCORP), a national network for the conduct of clinical trials in the community setting, NCI requested that STPI assist in NCORP's implementation. In FY 2018, STPI conducted analyses of the degree to which the 2014–2017 awards made to Sites and Research Bases under the NCORP conformed to the funding guidance set forth in the 2013 NCORP Guidelines. The analyses demonstrated that the awards did not conform to the Guidelines nor would it be feasible to make awards in accordance with the Guidelines. STPI developed funding approaches that conformed to the principles of the Guidelines and would be feasible to implement. Using these approaches, STPI also developed implementation tools and user guides for calculating annual awards.

Clinical trials system

STPI initiated this project by first facilitating deliberations of the NCI Clinical Trials Informatics Working Group (CTIWG), which developed recommendations for the NCI Clinical Trials Reporting Program (CTRP) in the areas of data access, expansion, and reporting; resolved data inconsistencies and ambiguities; and analyzed the use of CTRP data for clinical trials searching and clinical trial activity reporting. In FY 2018, STPI prepared a strategy for a comprehensive assessment of the NCI late-phase clinical trials portfolio and prepared a variety of materials for the conduct of such an assessment under the auspices of the Clinical Trials Strategic Assessment Working Group of the NCI Clinical and Translational Research Advisory Committee.

Cancer research programs

The NCI Center for Research Strategy (CRS) analyzes and reports on NCI research programs, and forecasts future NCI research needs. CRS asked STPI to work (1) with NCI program managers and stakeholders to conceptualize and define evaluation methodologies relevant to NCI cancer research programs, and (2) with the Office of Science Planning and Assessment to synthesize a diversity of NCI evaluation studies and evaluate lessons learned regarding unique institute initiatives. Also in FY 2018, STPI worked with CRS to develop an evaluation strategy for NCI activities conducted under the Beau Biden Cancer Research Moonshot.

STPI has supported the trans-NCI Informatics Technology for Cancer Research (ITCR) Program since 2012. ICTR sponsors investigator-initiated development of informatics technology critically needed in cancer research. In FY 2018, STPI facilitated an expert panel process intended to provide evaluative insights regarding the program's rationale and impact to date; surveyed current and former ICTR awardees to identify the program's role in fostering collaboration; and conducted a set of case studies of ICTR impact at an award level. The ICTR leadership used the results of these studies to inform the content of the next ICTR Funding Opportunity Announcement and the supporting justification statements and analyses explaining the value of the renewal.

Grant-writing mentorship

The NIH Funding Disparity Working Group (FDWG) gathers new data to characterize the factors associated with a persistent racial disparity in obtaining an investigator- initiated NIH Research Project Grant (R01). The FDWG determined that NIH grant applications submitted by African American/Black (AA/B) investigators are less likely to be funded, and the investigators are less likely to revise and resubmit their applications. The FDWG developed a grant-writing coaching and mentoring program for AA/B investigators and asked STPI to evaluate whether this program is likely to affect the resubmission rate of R01 applications that were scored but not funded during initial submission, as well as the award rates and scores of the resubmitted proposals. In 2018, STPI identified the strategy to assess the program, created evaluation materials, and recruited the coaching groups.

PORTFOLIO EVALUATIONS

Framework for portfolio evaluation

At the request of the NSF's Directorate for Education and Human Resources, STPI developed a four-step research portfolio evaluation framework to assess research related to a specific theme or topic that spanned NSF's directorates. Elements of the framework stipulate data collection, logic models, and other approaches that identify themes and thematic portfolios, and mechanisms to assemble the data into a portfolio. In FY 2017, STPI reported an application of this framework to the Inclusion across the Nation of Communities of Learners that have been Underrepresented for Diversity in Engineering and Science (INCLUDES) program. STPI also assisted NSF and the Interagency Working Group on Inclusion in Science, Technology, Engineering, and Mathematics (STEM) in conducting a webinar for Federal agency officials about the influence of campus climate at universities on STEM education.

Operations and maintenance costs for NSF facilities

In September 2017, the National Science Board (NSB) asked STPI to assist in developing a response to the U.S. Senate Appropriations Subcommittee on Commerce, Justice, Science, and Related Agencies regarding concerns that the annual operations and maintenance (O&M) costs for NSF-funded research facilities are increasing faster than overall NSF spending and require an increasingly large percentage of the NSF appropriation. Specifically, NSB asked STPI to examine how other science agencies fund large facilities and make funding tradeoffs between the O&M of facilities and research; what levels of control exist at different agencies; and the extent to which congressional appropriations are driving facility budgets. STPI focused on NASA and the Department of Energy (DOE) Office of Science to answer these research questions, and highlighted areas where NSF could learn from other agencies. The final report was delivered to NSB in April 2018 and informed their public report on the large facilities, which was released in May 2018.

NSB review of NSF facilities and budget trends

STPI is also completing a multi-year project for NSB's Committee on Strategy and Budget and the Committee on Awards and Facilities. They asked STPI to perform analyses that enhance NSB's strategic planning, decision-making, understanding of tradeoffs and interconnections among facilities, and long-term budgetary trends. In FY 2018, STPI continued to evaluate the current composition and future direction of the facilities' portfolio and its budgetary impacts, and to develop historical summaries of NSB's past discussions and decisions on large research facilities. The summaries provide NSB with institutional memory by capturing key issues and themes in NSB discussions over time, promote greater situational awareness, and maintain continuity of oversight for more informed decision-making.

NSF evaluation workshops

STPI has been tasked by the NSF Evaluation and Assessment Capability (EAC) to assist in hosting a series of workshops on NSF evaluation and training needs. STPI assisted EAC in convening the first workshop in February 2018 to better understand the processes other agencies have undertaken to develop Federal agency learning agendas. The goal of the workshop was to share approaches used by NSF program directors and to learn about best practices and challenges that other agencies have developed in building learning agendas. STPI's synthesis of best practices from this workshop has been selected for presentation at the American Evaluation Association 2018 annual meeting as part of the prestigious "Presidential Strand," the series of sessions considered the best of the meeting. A second workshop—a training game on evaluation practices and knowledge brokering—was held in June. The goal of the workshop was to springboard planning and development of several NSF-wide strategic initiatives.

Assessment methods for the Advanced Research Projects Agency within the U.S. Department of Energy

The Advanced Research Projects Agency within the U.S. Department of Energy (ARPA-E) supports potentially transformational technology projects for energy efficiency; electricity generation, transmission, and distribution; and transportation fuels, energy storage, and vehicles. ARPA-E staff asked STPI to explore the optimal design for an assessment program or team at an agency like ARPA-E, to review assessment methodologies across Federal agencies, and to identify best practices. STPI collected and analyzed information obtained through review of reports on Federal assessment capabilities, agency program and budget documents, and science and technology evaluation methods. STPI also conducted interviews of assessment methodology subject matter experts and agency assessment office staff. STPI developed four assessment models for ARPA-E consideration.

Roadmap for Frontier Observatory for Research in Geothermal Energy initiative

The DOE Geothermal Technologies Office (GTO) established the Frontier Observatory for Research in Geothermal Energy (FORGE) initiative to enable cutting-edge research on, and technology development for, Enhanced Geothermal Systems (EGS)—engineered subsurface reservoirs from which geothermal heat is harvested to generate electricity. The GTO asked STPI to research, design, and develop a roadmap for its FORGE initiative that would identify research actions and operational milestones that, if successfully executed, will help FORGE achieve its goals. To this end, STPI conducted a literature review, expert interviews, and a workshop to examine the current state of EGS research, identify technical challenges and research needs, and generate recommendations to address those challenges relative to DOE priorities and the FORGE geographical

locations. The FORGE Roadmap identifies three critical research areas (stimulation planning and design, fracture control, and reservoir management), describes research actions to further EGS development, and recommends FORGE site implementation principles. The FORGE Roadmap was published in February 2019.

PROVIDING TECHNICAL AND ANALYTIC SUPPORT



NATIONAL STRATEGIES, ROADMAPS, ACTION PLANS, AND INITIATIVES

Veteran suicide prevention research

Military veterans accounted for approximately 22 percent of the nearly 45,000 U.S. suicide deaths in 2016. Given the complexity of factors contributing to a decision to commit suicide and the limitations in current data sources on the causes and prevention of suicide, OSTP asked STPI to evaluate ongoing activities, relevant entities, and Federal efforts to advance veteran suicide prevention research. STPI examined the state of the science through literature reviews; analyzed current initiatives and programs; and assessed current Federal research and development (R&D) activities and plans for suicide prevention-related programs. STPI identified research on risk factors, improvements in data and surveillance systems, and development and testing of promising interventions as important areas for Federal activities. STPI's analysis will serve as the foundation for the interagency research strategy on prevention of veteran suicide and may inform executive action and policies.

Opioid Health S&T Roadmap

The opioid crisis is a national public health emergency, and a Presidential Memorandum outlines the role of the Federal Government in addressing the epidemic. OSTP is leading an interagency effort to coordinate health-focused Federal Government R&D activities related to the opioid crisis and link them with private sector and intergovernmental capabilities and needs. OSTP asked STPI to assist in leading an NSTC Fast Track Action Committee (FTAC) charged with developing an Opioid Health S&T Roadmap that will include current initiatives and programs at departments and agencies; an assessment of research gaps and challenges; and identification of Federal activities and investments needed to respond to the crisis. STPI conducted preliminary analysis of information on current initiatives and programs and assessed data needs, knowledge gaps, and challenges to implementation and coordination of Federal efforts. STPI also assisted the FTAC in identifying investments, activities, and resources to address the gaps and challenges. STPI's work directly informed the NSTC report, *Health Research & Development to Stem the Opioid Crisis: A National Roadmap*, which identifies seven areas of R&D critical to addressing key gaps in knowledge and tools, as well as opportunities to improve coordination of Federal R&D essential to combating the opioid crisis. A draft of this report was released for public comment in October 2018, and the final report will be released in 2019.

Contaminants of emerging concern

The NSTC Contaminants of Emerging Concern Task Force (TF) was chartered to respond to a congressional request to develop a cross-agency plan for addressing critical research gaps related to contaminants of emerging concern (CECs) in drinking water. OSTP asked STPI to participate in the preparation of the plan by producing a series of informational reports and facilitating the development of the cross-agency plan. STPI developed two reports that provide background

and contextual information for OSTP and the TF by summarizing the state of the science for CECs in drinking water as it relates to (1) detection, characterization, and quantification of contaminants, and (2) human health impacts of exposure. Additionally, OSTP asked STPI to support the work of three TF writing teams and to assist OSTP in the development of the final strategy, *Coordinated Cross-agency Plan for Addressing Critical Research Gaps Related to Emerging Contaminants*. The plan was sent to Congress in September 2018.

NATIONAL SCIENCE AND TECHNOLOGY COUNCIL SUPPORT

The NSTC is the principal means to coordinate science and technology (S&T) policy across the agencies and offices of the executive branch of the Federal Government. It is located organizationally within OSTP.

Organizational support for the National Science and Technology Council

In 2018, NSTC began a restructuring process with the goals of streamlining the committees and subcommittees, reinvigorating subcommittee membership, and emphasizing deliverables and outcomes. The NSTC Executive Director asked STPI to assist with the development of a new NSTC Handbook that describes the roles and responsibilities of members of the NSTC committees, subcommittees, and supporting staff; procedures for developing reports and other deliverables; and other relevant process information.

STEM education

The America COMPETES Reauthorization Act charged the NSTC Committee on STEM Education (CoSTEM) with the coordination of Federal STEM education programs and OSTP with progress updates. To meet the COMPETES requirements, OSTP asked STPI to support CoSTEM activities by providing research, analysis, writing team support, and draft materials in support of the 2018–2023 Federal STEM Education 5-Year Strategic Plan, *Charting a Course for Success: America's Strategy for STEM Education*. This strategy was published in December 2018.

STPI also developed a Federal STEM program inventory and analyzed program characteristics such as funding investment, progress in key areas identified in the current Federal STEM plan, and topics for future STEM efforts. STPI generated a summary report of its findings, which then informed the OSTP report, *2018 Federal STEM Education Progress Report*.

Research and development infrastructure

The Subcommittee on National Security Laboratories Research, Development, Test, and Evaluation Facilities and Infrastructure was restructured as the Subcommittee on R&D Infrastructure, one of five cross-cutting subcommittees under a new NSTC Committee on S&T Enterprise. STPI supported strategic planning of the Subcommittee on R&D Infrastructure and identified opportunities for collaboration with other NSTC subcommittees in FY 2018–19.

Interagency Working Group support

STPI also worked with OSTP and Office of Management and Budget during FY 2015–18 to establish an interagency U.S. Group on Earth Observations (USGEO)

Satellite Needs Working Group (SNWG) through which civil agencies are able to provide NASA with unmet or continuity observation needs for consideration in their systems engineering process. STPI worked with the SNWG in FY 2018 to conduct the second collection cycle, capturing 74 unique space-based observing needs from civil agencies for NASA consideration and began analyzing the technical parameters of those needs and their potential application areas through comparison with Earth Observation Assessment results.

