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MEMORANDUM FOR THE HEADS OF EXECUTIVE DEPARTMENTS AND AGENCIES

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SUBJECT: Fiscal Year (FY) 2022 Administration Research and Development Budget Priorities
and Cross-cutting Actions

"We look at tomorrow and see unlimited frontiers just waiting to be explored. Our brightest discoveries are not yet known. Our most thrilling stories are not yet told. Our grandest journeys are not yet made..."

President Donald J. Trump, 2020 State of the Union Address

Over the past 75 years, the United States has emerged as the unquestioned global leader in science and technology (S&T) research and innovation. The importance of this leadership has never been clearer than in our whole-of-Nation response to the COVID-19 pandemic. The sum total of decades of public and private investment in research and development (R&D) has served as the foundation for rapidly characterizing the SARS-CoV-2 virus and developing life-saving diagnostics and medical interventions. The Trump Administration's focus on the Industries of the Future (IoF) and, in particular, artificial intelligence (AI) has equipped researchers with new and better tools to fight the disease. Likewise, investments in advanced communications, networking, and broadband access have ensured that millions of Americans can continue to work and access education and medical services remotely.

A foundation of the Nation's ability to respond to COVID-19 is the capacity of government, the private sector, academia, and nonprofits to make substantial and complementary investments in R&D and effectively partner to create the discoveries and innovations. This same partnership fuels the economic prosperity, health, and security of all Americans. The Federal Government, in particular, serves as a catalyst for innovation by investing in early stage research, supporting workforce education and training, and optimizing research environments by streamlining administrative barriers and adhering to bedrock American values, such as free inquiry, competition, honesty, and inclusion.

OVERVIEW OF THE FY2022 MEMORANDUM

For FY2022, the *five R&D budgetary priorities* in this memorandum ensure that America remains at the global forefront of S&T discovery and innovation. The IoT—AI, quantum information sciences (QIS), advanced communication networks/5G, advanced manufacturing, and biotechnology—remain the Administration’s top R&D priority. This includes fulfilling President Trump’s commitment to double non-defense AI and QIS funding by FY2022.

In light of the significant health and economic disruption caused by the COVID-19 pandemic, the FY2022 memorandum includes a new R&D priority aimed at *American Public Health Security and Innovation*. This priority brings under a single, comprehensive umbrella biomedical and biotechnology R&D aimed at responding to the pandemic and ensuring the U.S. S&T enterprise is maximally prepared for any health-related threats.

Lastly, this memorandum also describes *four high-priority crosscutting actions*. These actions include research and related strategies that underpin the five R&D priorities and ensure departments and agencies deliver maximum return on investment to the American people.

R&D BUDGETARY PRIORITIES

1. American Public Health Security and Innovation

R&D to strengthen and safeguard the health and quality of life of individuals, families, and communities is a top priority for the Trump Administration. COVID-19 has highlighted the extent to which public health threats and challenges can impact economic and national security. The Administration is committed to focusing on R&D initiatives that improve health while ensuring a retooled economy that optimizes innovation.

Diagnostic, Vaccine, and Therapeutic R&D: As has been demonstrated with COVID-19, the importance of detection, prevention, response, and control to protect all Americans against infectious diseases or other bio-threats is paramount and requires the coordinated effort of all relevant departments and agencies. Departments and agencies should continue to support R&D that will contribute to timely development of modernized devices and equipment, diagnostics, therapeutics, and vaccines within the medical countermeasures enterprise.

Infectious Disease Modeling, Prediction, and Forecasting: The United States must improve epidemiological modeling R&D, as well as use such models on a continuous basis rather than employing them only in times of crisis. Relevant departments and agencies should enhance their ability to predict future pandemics by continuing to advance data and forecasting science to inform a more streamlined, better coordinated, and continual whole-of-society approach to addressing future infectious disease outbreaks.

Biomedicine and Biotechnology: Departments and agencies should prioritize accelerated identification and selection of R&D investments including the rapid detection, containment, and treatment of infectious diseases. Topics include pharmaceutical and non-pharmaceutical interventions, personalized medicine, neuroscience, and opioids, and advancing other IoT areas such as AI and advanced manufacturing—technologies that have been critical in ensuring rapid R&D of vaccines and therapeutics for pathogens such as COVID-19.

Bioeconomy: The American Bioeconomy represents a convergence of science, infrastructure, innovation and technology, health, and national security that drive economic growth, promote health, and increase public benefit across the human, plant, and animal spectrums. In response to the unprecedented number of lives lost and resources consumed to combat COVID-19, departments and agencies should prioritize evidence-based standards and research to rapidly and strategically continue improving biotechnology infrastructure that support human, plant, and animal safety. In addition, departments and agencies should focus on R&D that enables forecasting and analyses from comprehensive collections of epidemiological, clinical, and genomic data capable of driving supply chain resilience and economic growth across sectors such as healthcare and pharmaceuticals, engineering biology, nanobiotechnology, agriculture, and IoT including advanced manufacturing.

2. American Leadership in the Industries of the Future and Related Technologies

The Trump Administration continues to prioritize the science and technologies that power IoT—AI, QIS, advanced communications networks/5G, advanced manufacturing, and biotechnology¹—as well as the future computing ecosystem that underpins advances in IoT, and the autonomous and remotely piloted vehicles that are enabled by IoT. These industries promise to fuel American prosperity, improve quality of life and national security, and create high-paying jobs for American workers. Some of the industries are also key enablers in our response to and recovery from COVID-19 and its impacts. Sustained, strategic R&D investment in these emerging technologies and the supporting future computing ecosystem will better position the Nation for handling future crises and catalyzing discoveries and innovations that will shape the global S&T landscape for the decades ahead.² Additionally, research at the convergence of these industries with pathfinders such as advanced air mobility that integrates AI, autonomy, advanced manufacturing, and next-generation communications, will accelerate new discoveries that fuel future breakthroughs and yield a near-term economic and national security advantage.

Artificial Intelligence: Departments and agencies should prioritize research investments consistent with the *Executive Order on Maintaining American Leadership in Artificial Intelligence*³ and the 2019 update of the *National Artificial Intelligence Research and Development Strategic Plan*.⁴ Transformative basic research priorities include research on ethical issues of AI, data-efficient and high performance machine learning (ML) techniques, cognitive AI, secure and trustworthy AI, scalable and robust AI, integrated and interactive AI, and novel AI hardware. The current pandemic highlights the importance of use-inspired AI research for healthcare, including AI for discovery of therapeutics and vaccines; AI-based search of publications and patents for scientific insights; and AI for improved imaging, diagnosis, and data analysis. Beyond healthcare, use-inspired AI research for scientific and engineering discovery across many domains can help the Nation address future crises. AI infrastructure investments are prioritized, including national institutes and testbeds for AI development, testing, and evaluation; data and model resources for AI R&D; and open knowledge networks. Research is also prioritized for the development of AI measures, evaluation methodologies, and standards, including quantification of trustworthy AI in dimensions of accuracy, fairness, robustness, explainability, and transparency.

¹ See Priority 1, “Public Health Security and Innovation,” for discussion of the IoT biotechnology priority areas.

² President’s Council of Advisors on Science and Technology, “Recommendations for Strengthening American Leadership in Industries of the Future,” https://science.osti.gov/-/media/_pdf/about/pcast/202006/PCAST_June_2020_Report.pdf.

³ Exec. Order No. 13859, “Maintaining American Leadership in Artificial Intelligence,” 84 Fed. Reg. 3967 (Feb. 11, 2019).

⁴ National Science and Technology Council (NSTC), “The National Artificial Intelligence Research and Development Strategic Plan: 2019 Update.” <https://www.nitrd.gov/pubs/National-AI-RD-Strategy-2019.pdf>.

Quantum Information Science: Consistent with the 2018 *National Quantum Initiative Act*⁵ and the 2018 *National Defense Authorization Act*,⁶ departments and agencies should pursue quantum frontiers by prioritizing approaches for enabling and invigorating the nascent QIS ecosystem while deepening focused efforts, such as centers, core programs, and novel quantum networking collaborations. Opportunities to encourage collaboration between efforts and agencies should be prioritized, as should support for pre-competitive R&D through mechanisms such as consortia and other technology translation efforts, investment in critical infrastructure and testbeds in concert with work on future computing paradigms and advanced manufacturing to enable next-generation quantum devices, and expansion of efforts exploring and piloting uses of quantum technology to help support agency missions.

Advanced Communications Networks: Departments and agencies, in close coordination with the private sector, should strengthen basic research in advanced communications technologies, including furthering America's leadership in 5G and beyond wireless networks, in order to spur innovation and growth. As outlined in the report *Research and Development Priorities for American Leadership in Wireless Communications*,⁷ this includes research on AI/ML techniques optimized for wireless systems, as well as applying AI/ML to communications and cyber security in general, toward the goal of secure and trusted applications. Departments and agencies should encourage the development of applications that leverage 5G and advanced networks that incorporate security and privacy as fundamental values. Departments and agencies should support growth in American manufacturing of wireless network equipment through R&D of open, interoperable, secure-by-design, modularized network architectures.⁸

Advanced Manufacturing: Department and agency R&D investments should support the goals in the report *Strategies for American Leadership in Advanced Manufacturing*.⁹ Priorities include smart and digital manufacturing and advanced industrial robotics, especially systems enabled by the industrial internet of things. Departments and agencies should focus on methods for low-cost distributed manufacturing and continuous manufacturing, including investments in bio-based manufacturing to ensure domestic access to needed medicines. An area of particular importance is the development of nano and advanced materials and processes in the biomedical arena to support the Nation's response to COVID-19, such as the development of effective antimicrobial materials and polymers for additive manufacturing and prototyping of critical medical devices.

IotF-Related Technology – Future Computing Ecosystem: To accelerate IotF, departments and agencies should prioritize the implementation of a national strategic computing ecosystem as outlined in the report *National Strategic Computing Initiative Update: Pioneering the Future of*

⁵ Pub. L. No. 115-368.

⁶ Pub. L. No. 115-91.

⁷ OSTP, "Research and Development Priorities for American Leadership in Wireless Communications," <https://www.whitehouse.gov/wp-content/uploads/2019/05/Research-and-Development-Priorities-for-American-Leadership-in-Wireless-Communications-Report-May-2019.pdf>.

⁸ Exec. Order No. 13873, "Securing the Information and Communications Technology and Services Supply Chain," 84 Fed. Reg. 65316 (May 15, 2019).

⁹ NSTC, "Strategy for American Leadership in Advanced Manufacturing,"

<https://www.manufacturing.gov/news/announcements/2018/10/strategy-american-leadership-advanced-manufacturing>.

Computing,¹⁰ integrating advanced computing, software, and data resources from extreme scales to the edge towards enabling end-to-end application workflows, while supporting innovations in and translation of future technologies. This includes prioritizing investments in fundamental R&D in future computing technologies and paradigms including testbeds, experimental systems, and prototypes. To amplify the transformative impact of a strategic computing ecosystem as demonstrated by the successes of the COVID-19 HPC Consortium,¹¹ departments and agencies should explore innovative models for resource aggregation and sharing and for public-private partnerships.¹² Priorities include translational efforts such as consortia or centers of excellence that leverage such partnerships towards the development and sustainability of software and data solutions.

IoT-Related Technology – Autonomous and Remotely Piloted Vehicles: Leveraging emerging IoT technologies, departments and agencies should prioritize R&D that enables surface, air, and maritime autonomous and remotely piloted vehicles, and optionally piloted electric vertical-takeoff-and-landing aircraft. They should prioritize R&D to lower barriers to the deployment of surface, air, and maritime autonomous vehicles with a focus on developing operating standards including sense and avoid technologies, integration approaches, traffic management systems, and defense/security operations including technology to aid law enforcement policing of autonomous and remotely piloted transportation systems. This includes technology to aid regulators in quickly and effectively validating the safety and security of advanced transportation technologies. Departments and agencies should also prioritize civil supersonic aircraft, including for type certification, the creation of over-land supersonic flight noise standards, and low-sonic-boom aircraft research.

3. American Security

The 2017 National Security Strategy¹³ states “[a]n America that is safe, prosperous, and free at home is an America with the strength, confidence, and will to lead abroad. It is an America that can preserve peace, uphold liberty, and create enduring advantages for the American people.” Preserving and protecting American security requires targeted Federal Government investments in R&D leading to robust and flexible capabilities for preventing and responding to evolving challenges posed by strategic competitors and adversaries, as well as those that arise from the natural world.

Resilience: Departments and agencies should invest in R&D that improves the safety and resilience of American individuals, businesses, communities, government, and society. This should include R&D to enhance capabilities for anticipating, preventing, responding to, and/or recovering from physical threats and natural disasters, including compound and cascading incidents. Such R&D should encompass and, as appropriate, integrate across threat and hazard domains, including infectious diseases and other biological threats, extreme terrestrial and space weather events, geophysical hazards, cyber and electromagnetic pulse attacks on critical infrastructure, and exploitation of supply chain vulnerabilities.

¹⁰ Fast Track Action Committee on Strategic Computing, “National Strategic Computing Initiative Update: Pioneering the Future of Computing,” November 2019. <https://www.whitehouse.gov/wp-content/uploads/2019/11/National-Strategic-Computing-Initiative-Update-2019.pdf>.

¹¹ “COVID-10 High Performance Computing Consortium,” <https://www.whitehouse.gov/briefings-statements/white-house-announces-new-partnership-unleash-u-s-supercomputing-resources-fight-covid-19/>.

¹² See cross-cutting actions 2 and 4, for additional actions to support partnerships and data sharing, respectively.

¹³ <https://www.whitehouse.gov/wp-content/uploads/2017/12/NSS-Final-12-18-2017-0905.pdf>.

Advanced Military Capabilities: Relevant departments and agencies should invest in R&D to deliver the advanced military capabilities necessary for meeting emerging threats and protecting American security into the future, including offensive and defensive hypersonic weapons capabilities, resilient national security space systems, and modernized and flexible strategic and nonstrategic nuclear deterrent capabilities. Departments and agencies should seek to develop technology approaches that can shorten defense acquisition cycles and increase our responsiveness to emerging military threats in all domains, including space and cyber.

Semiconductors: Departments and agencies, working together and in collaboration with industry and academic partners where appropriate, should prioritize investments to ensure government access to trusted and assured microelectronics and continued American leadership in semiconductor technologies, including the underlying materials, devices, designs, and software; and the fabrication and characterization tools and facilities required for advanced microelectronics.

4. American Energy and Environmental Leadership

Advancing energy technologies to assure a secure and abundant energy supply, understanding our unexplored ocean and expanding use of ocean data, improving our Earth system prediction capabilities, and the Arctic are Administration priorities that will enhance the Nation's economic vitality, national security, and environmental quality and are critical to the well-being and prosperity of all Americans.

Energy: Departments and agencies should invest in early-stage, innovative R&D into technologies that show promise for harnessing American energy resources safely and efficiently, inclusive of nuclear, renewable, and fossil energy. Federally-funded energy R&D should continue to reflect an increased reliance on the private sector to fund later-stage research, development, and commercialization of energy production, storage, and consumption technologies, while also supporting user facilities that can improve multisector collaboration. Department and agencies should invest in nuclear energy R&D, including further development of advanced reactor technologies.

Earth System Predictability and Meteorological Services: The United States aspires to lead the world in meteorological services via an Earth system approach that encompasses weather, climate, hydrologic, ocean, and related environmental topics—providing societal benefits with information spanning highly local to global impacts. Departments and agencies should prioritize, coordinate, and collaborate to implement a national strategy to accelerate progress in improving the theoretical understanding and practical utilization of predictability, reducing gaps in the observation of crucial processes, and exploring advanced modeling capabilities using non-traditional approaches such as AI. Departments and agencies should prioritize the availability of adequate computing and data infrastructure and technology to enable this research; they also should collaborate closely on the most effective use of research resources via coordination and partnerships.

Oceans: To advance implementation of the Presidential Memorandum on ocean mapping,¹⁴ departments and agencies should continue to prioritize new and emerging technologies and collaborative approaches to efficiently map, explore, and characterize the resources of the U.S. exclusive economic zone. Departments and agencies should also focus on increasing their capacity to effectively and efficiently manage large volumes of ocean observation and research data, and make it available to the Federal government and stakeholders.¹⁵ Departments and agencies should continue to prioritize R&D that improves understanding of and supports effective responses to changes in the ocean system, such as ocean chemistry.

Arctic: The United States is an Arctic nation, and the rapidly changing conditions in the Arctic have national security, commerce, and transportation implications that other nations are already addressing. Departments and agencies should prioritize research investments that enhance our ability to observe, understand, and predict the physical, biological, and socio-economic processes of the Arctic to protect and advance American interests.

5. American Space Leadership

R&D investments should continue to leverage efforts underway at American universities and in the private sector and focus on ensuring American leadership in space by supporting the Trump Administration's call for a return of Americans to the Moon's surface by 2024 for long-term exploration and utilization, and as a proving ground for future human missions to Mars. Microgravity research in biological and physical science on new platforms in Low Earth Orbit is important to enabling longer duration human missions in space and may have practical benefits to life on Earth.

Departments and agencies should prioritize in-situ resource utilization on the Moon and Mars, cryogenic fuel storage and management, in-space manufacturing and assembly, advanced space-related power and propulsion capabilities, and orbital debris management. Departments and agencies should also prioritize activities that ensure an industrial base for commercial activity in space and that will broadly speed private-sector progress in meeting stated Government goals and furthering the space economy. Finally, departments and agencies should seek opportunities to work with advanced materials, additive manufacturing, and machine learning capabilities that have broad potential applications in space and on Earth.

PRIORITY CROSSCUTTING ACTIONS

1. Build the S&T Workforce of the Future

Harmonized investments in R&D and S&T workforce advance the Nation's economic prosperity and national security. The foundation of these investments is the STEM ecosystem—a cross-sector collaborative effort that provides all Americans with access to high-quality STEM education and advanced workforce pathways throughout their lifetimes. Consistent with the Federal strategic plan for STEM education, *Charting a Course for Success: America's Strategy for STEM Education* (STEM Strategic Plan),¹⁶ departments and agencies should prioritize investments in

¹⁴ Memorandum on Ocean Mapping of the United States Exclusive Economic Zone and the Shoreline and Nearshore of Alaska, <https://www.whitehouse.gov/presidential-actions/memorandum-ocean-mapping-united-states-exclusive-economic-zone-shoreline-nearshore-alaska/>.

¹⁵ See Cross-cutting Action 4, "Leverage the Power of Data," for additional actions to facilitate safe and effective use of data.

¹⁶ <https://www.whitehouse.gov/wp-content/uploads/2018/12/STEM-Education-Strategic-Plan-2018.pdf>.

research programs and other related activities that advance innovation in STEM education and increase diversity, equity, and inclusion in STEM.

To further these goals, departments and agencies should prioritize education investments that: (1) support learning through the development of infrastructure and tools for delivery of both remote and in-person learning; (2) develop mechanisms to attract, prepare and support all Americans to pursue STEM pathways, especially for underrepresented and underserved populations; (3) create effective experiential and work-based learning opportunities to engage students in STEM; (4) develop the next generation of teachers and faculty prepared to advance STEM education; (5) expand broadband access and improve teaching and learning modalities for remote learners; and (6) ensure a robust pipeline of American students capable of pursuing graduate degrees in STEM. Research advances and best practices in STEM teaching and learning should be disseminated throughout the STEM ecosystem to ensure high levels of STEM literacy for all Americans.

2. Optimize Research Environments and Results

To advance S&T progress and ensure maximum return on taxpayer investment in R&D, any setting where R&D is performed must welcome all individuals without prejudice. Consistent with American values, investigators, students, postdoctoral scholars, and technicians should be able to work safely, efficiently, and ethically, and be treated with respect. In addition, in accordance with the President's Management Agenda (PMA) CAP Goal 8, "Results-Oriented Accountability for Grants," departments and agencies should enhance efficiencies, reduce unnecessary burdens, and improve successful results for the American taxpayer.

Four high-priority areas related to research environments require significant attention:

- Strengthening the security of U.S. research enterprise;
- Reducing administrative burdens on federally-funded research; continue efforts to streamline and coordinate Federal grant policies and processes consistent with PMA CAP Goal 8,¹⁷ including use of shared profile systems and persistent identifiers; identify opportunities to institutionalize effective practices for accelerating research and innovation developed in response to COVID-19;
- Improving rigor and integrity in research; prioritize research on training and resources that promotes rigor, transparency, and integrity. Coordinate efforts with academic institutions, philanthropic organizations, publishers, and other stakeholders to foster rigorous practices; and
- Creating safe, diverse, inclusive, and equitable research environments for all members of the research enterprise, paying particular attention to the burdens COVID-19 has placed on the S&T workforce.

¹⁷ PMA CAP Goal 8 is working to streamline administrative burdens associated with all Federal grant programs and maximize the value of grant funding by applying a risk-based, data-driven framework that balances compliance requirements with demonstrating successful improve efficiencies, reduce unnecessary burdens, and improve successful results for the American taxpayer.

Departments and agencies should ensure that their R&D investments improve intramural and extramural research environments that address these four action areas, and actively coordinate and collaborate with other R&D departments and agencies, via the National Science and Technology Council Joint Committee on the Research Environment, to ensure that R&D investments and policies are aligned with the four priority areas.¹⁸

3. Facilitate Multisector Partnerships and Technology Transfer

America's continued economic growth and recovery from the COVID-19 pandemic is strongly rooted in securing and reinforcing multisector partnerships in S&T. The commercialization of federally-funded research and outcomes of lab to market strategies are substantially increased through partnership agreements, licensing, and successful startups. Departments and agencies should develop the skills and prioritize the resources to "Improve Transfer of Federally-Funded Technologies from Lab-to-Market" by further advancing this objective of the President's Management Agenda (PMA) Cross-Agency Priority (CAP) Goal 14.¹⁹

Departments and agencies should consider initiatives to ease administrative and regulatory burdens for Federal technology transfer to increase private sector investment in R&D and innovative processes and services to support IoT. Additionally, effective partnering tools, resources and technology transfer mechanisms for departments and agencies should be developed, clarified, and released for public consumption to stakeholders. Departments and agencies should prioritize funding for cooperative projects that align organizational incentives and advance new external partnership opportunities through multisector engagement.

Departments and agencies should facilitate increased interagency collaboration and transparency to strengthen coordination on existing and new partnerships that improve place-based and national-level collaboration for innovation economies, such as those in Opportunity Zones, underrepresented populations, and Historically Black Colleges and Universities (HBCUs) and minority serving institutions (MSIs) through multisector engagement that accelerates entrepreneurship and innovation to support the next generation of industry leaders.

4. Leverage the Power of Data

Data is increasingly critical for research and innovation, accountability and transparency, and evidence-based policymaking. The PMA CAP Goal 2, "Leveraging Data as a Strategic Asset,"²⁰ describes three objectives: develop a long-term, enterprise-wide Federal Data Strategy to better govern and leverage the Federal Government's data; enable Government data to be accessible and useful for the American public, businesses, and researchers; and improve the use of data for decision-making and accountability for the U.S. Government, including for policy-making, innovation, oversight, and learning.

Department and agency investments should reflect and support the objectives of CAP Goal 2 and the Federal Data Strategy framework, especially the *2020 Action Plan*.²¹ Departments and agencies should also prioritize R&D aimed at improving data accessibility and security, including

¹⁸ Agencies should also actively participate on the PMA CAP Goal 8 workgroups to help build shared solutions that would contribute to reducing administrative burden and improving results.

¹⁹ <https://www.performance.gov/CAP/lab-to-market/>

²⁰ The Federal Data Strategy, [http://strategy.data.gov. \(2020\).](http://strategy.data.gov. (2020).)

²¹ <https://strategy.data.gov/action-plan/>

fundamental research into efficient privacy and security preserving techniques and building and/or strengthening infrastructure, platforms, and tools that facilitate responsible data use. Departments and agencies should coordinate and collaborate with each other and non-Federal stakeholders to drive discovery and innovation in high priority areas, such as biomedicine and biotechnology, by leveraging AI/ML and other technologies, tools, platforms, and protocols. Departments and agencies should also make their data discoverable, accessible and useable, consistent with all applicable laws, regulations, and policies governing data use, disclosure, and sharing.