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MEMORANDUM FOR THE HEADS OF EXECUTIVE DEPARTMENTS AND AGENCIES

FROM: RUSSELL T. VOUGHT
ACTING DIRECTOR, OFFICE OF MANAGEMENT AND BUDGET

DR. KELVIN K. DROEGEMEIER
DIRECTOR, OFFICE OF SCIENCE AND TECHNOLOGY POLICY

SUBJECT: Fiscal Year 2021 Administration Research and Development Budget Priorities

"We stand at the birth of a new millennium, ready to unlock the mysteries of space, to free the Earth from the miseries of disease, and to harness the energies, industries, and technologies of tomorrow."

President Donald J. Trump, 2017 Inaugural Address

America's rise as the global leader in science and technology (S&T) began shortly after World War II, during which the Federal Government began investing significantly in basic and applied research, infrastructure, and education across many disciplines. From then until now—during America's First Bold Era in S&T—these Federal investments helped create a massive, multisector American S&T enterprise consisting of Federal agencies, world-leading colleges and universities, private industry, non-profit organizations, and Federal and National Laboratories.

The resulting extraordinary discoveries and innovations laid the foundation for today's Second Bold Era in S&T—one characterized by unprecedented knowledge, access to data and computing resources, ubiquitous and instant communication, and technologies that allow us to peer into the inner workings of atomic particles as well as the vastness of the universe. Unfortunately, this Second Bold Era also features new and extraordinary threats which must be confronted thoughtfully and effectively.

The Trump Administration is firmly committed to continuing American S&T leadership in the Second Bold Era. Success will depend, in large part, on our ability to leverage—in entirely new and creative partnership and collaborative frameworks—the multisector S&T enterprise that emerged during the First Bold Era. It will depend upon striking a balance between the openness of our research ecosystem and the protection of our ideas and research outcomes. It will depend upon ensuring that our research environments are diverse, safe, inclusive, and accommodating as well as free from unnecessary administrative burdens. Success will depend upon ensuring that research is conducted with integrity and respect, which are foundational not only to the research process, but to the trust placed in the research enterprise by American taxpayers and reflective of America's values.

This Fiscal Year 2021 (FY2021) R&D Budget Priorities memorandum provides direction to enable this Second Bold Era as part of a longer-term, multisector, national strategy to advance bold, transformational leaps in S&T, build a diverse workforce of the future, solve previously intractable grand challenges, and ensure America remains the global S&T leader for generations to come.

GENERAL GUIDANCE FOR FY2021

For FY2021, the ***five R&D budgetary priorities*** in this memorandum ensure that America remains at the forefront of scientific progress, national and economic security, and personal well-being, while continuing to serve as the standard-bearer for today's emerging technologies and Industries of the Future. This memorandum also describes ***five high-priority crosscutting actions*** that span all five R&D budgetary priorities and require departments and agencies to coordinate, collaborate, and partner with one another and with the other sectors of the S&T enterprise to maximize success.

R&D BUDGETARY PRIORITIES

1. American Security

The 2018 *National Defense Strategy* calls for leadership in research, technology, invention, and innovation to "ensure we will be able to fight and win the wars of the future."[1] As adversaries leverage emerging and disruptive technologies to threaten the Nation, it is imperative that we invest in R&D to remain at the leading edge of S&T, maintain military superiority, remain agile in the face of existing and new threats, and keep the American people safe.

Advanced Military Capabilities: Relevant departments and agencies should invest in R&D to deliver the advanced military capabilities that will help meet emerging threats and protect 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.

Critical Infrastructure Resilience: Departments and agencies should invest in critical infrastructure R&D that improves resilience to natural disasters and physical threats, including extreme terrestrial events, cyber and electromagnetic pulse attacks, and exploitation of supply chain vulnerabilities. Departments and agencies should prioritize investments in space weather R&D according to the 2019 *National Space Weather Strategy and Action Plan*[2] and, where applicable, pay specific attention to improving research to operations and operations to research capabilities.

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[1] Department of Defense. "Summary of the 2018 National Defense Strategy of the United States of America." https://dod.defense.gov/Portals/1/Documents/pubs/2018-National-Defense-Strategy-Summary.pdf.
[2] NSTC. "National Space Weather Strategy and Action Plan." https://www.whitehouse.gov/wp-content/uploads/2019/03/National-Space-Weather-Strategy-and-Action-Plan-2019.pdf.

Semiconductors: Departments and agencies, working in collaboration with industry and academic partners where appropriate, should prioritize investments that will enable whole of government access to trusted and assured microelectronics for future computing and storage paradigms, consistent with the *Executive Order on Securing the Information and Communications Technology and Services Supply Chain*.[3]

Critical Minerals: The *Executive Order on a Federal Strategy to Ensure Secure and Reliable Supplies of Critical Minerals* identifies innovation and R&D as key to reducing vulnerabilities and building supply chain resilience for rare earths and critical minerals.[4] Priorities include developing recycling and reprocessing technologies, identifying substitute materials, and developing new and improved processes for critical mineral extraction, separation, refining, and alloying.

2. American Leadership in Industries of the Future

The Trump Administration continues to prioritize the technologies that power Industries of the Future (IotF). These industries promise to fuel American prosperity, improve quality of life and national security, and create high-paying jobs for American workers. Sustained, strategic R&D investment in these emerging technologies and the materials, manufacturing, and computing that support them will advance American S&T leadership in the short term and catalyze discoveries and innovations that will shape the global S&T landscape for the decades ahead.

Artificial Intelligence, Quantum Information Science, and Computing: Departments and agencies should prioritize basic and applied research investments that are consistent with the 2019 *Executive Order on Maintaining American Leadership in Artificial Intelligence*[5] and the eight strategies detailed in the 2019 update of the *National Artificial Intelligence Research and Development Strategic Plan*.[6] Consistent with the 2018 *National Quantum Initiative Act*[7] and the 2018 *National Defense Authorization Act*,[8] departments and agencies should prioritize R&D advancing fundamental QIS, building and strengthening the workforce, engaging industry, and providing infrastructure supporting QIS while coordinating relevant activities to ensure intelligence, defense, and civilian efforts grow synergistically. In terms of computing, departments and agencies should work together to explore new applications in and support R&D for high performance future computing paradigms, fabrication, devices, and architectures

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[3] Executive Order on Securing the Information and Communications Technology and Services Supply Chain. https://www.whitehouse.gov/presidential-actions/executive-order-securing-information-communications-technology-services-supply-chain/.
[4] A Federal Strategy to Ensure Secure and Reliable Supplies of Critical Minerals. https://www.commerce.gov/news/reports/2019/06/federal-strategy-ensure-secure-and-reliable-supplies-critical-minerals.
[5] Executive Order on Maintaining American Leadership in Artificial Intelligence. https://www.whitehouse.gov/presidential-actions/executive-order-maintaining-american-leadership-artificial-intelligence/.
[6] NSTC. "The National Artificial Intelligence Research and Development Strategic Plan: 2019 Update." https://www.nitrd.gov/pubs/National-AI-RD-Strategy-2019.pdf.
[7] Public Law 115-368.
[8] Public Law 115-91.

alongside sustainable and interoperable software; data maintenance and curation; and appropriate security.

Advanced Communications Networks and Autonomy: Departments and agencies should support the development and deployment of advanced communications networks by prioritizing R&D consistent with the National Spectrum R&D Strategy. They should prioritize R&D to lower barriers to the deployment of surface, air, and marine autonomous vehicles with a focus on developing operating standards, integration approaches, traffic management systems, and defense/security operations. Departments and agencies should prioritize R&D that enables electric vertical-takeoff-and-landing and civil supersonic aircraft, including for type certification, the creation of over-land supersonic flight noise standards, and low-sonic-boom aircraft research.

Advanced Manufacturing: Department and agency R&D investments should support the goals in the National Science and Technology Council (NSTC) 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, machine learning, and AI. 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.

3. American Energy and Environmental Leadership

Advancing energy technologies, understanding our unexplored ocean and expanding use of ocean data, and improving our Earth system prediction capabilities are Administration priorities that will enhance the nation's economic vitality, national security, and environmental quality.

Energy: Departments and agencies should invest in early-stage, innovative research and 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 and storage technologies, including supporting user facilities that can improve multisector collaboration. Relevant department and agencies should invest in nuclear energy R&D, including further development of advanced reactor technologies and reestablishing an American fast neutron irradiation capability through the versatile advanced test reactor.

Oceans: Departments and agencies should 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 processing and making publically available data that characterize natural resources and human activities and on

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[9] NSTC. "Strategy for American Leadership in Advanced Manufacturing." https://www.manufacturing.gov/news/announcements/2018/10/strategy-american-leadership-advanced-manufacturing.

R&D that improves understanding of and supports effective responses to changes in the ocean system.

Earth System Predictability: Knowing the extent to which components of the Earth system are practicably predictable – from individual thunderstorms to long-term global change – is vitally important for physical understanding of the Earth system, assessing the value of prediction results, guiding Federal investments, developing effective policy, and improving predictive skill. Departments and agencies should prioritize R&D that helps quantify Earth system predictability across multiple phenomena, time, and space scales. Strategic coordination and leveraging of resources across agencies on research and modeling efforts is needed to accelerate progress in this area. Additionally, agencies should emphasize how measures of and limits to predictability, both theoretical and actual, can inform a wide array of stakeholders. They also should explore the application of AI and adaptive observing systems to enhance predictive skill, along with strategies for obtaining substantial improvements in computational model performance and spatial resolution across all scales.

4. American Health & Bioeconomic Innovation

American medical and biotechnology breakthroughs have enhanced the quality and longevity of life for countless people around the world. The Trump Administration continues to focus R&D on key research breakthroughs and solutions that improve the health of our veterans and individuals of all ages, while enabling new opportunities in the Bioeconomy.

Biomedicine: Departments and agencies should prioritize R&D investments aimed at combatting the opioid crisis, rapid detection and containment of infectious diseases, anti-microbial resistance, chronic disease prevention and treatment, gene therapy, neuroscience, medical countermeasures and public health preparedness, eradicating HIV/AIDS once and for all, and enhancing the independence, safety, and wellness of aging Americans and individuals with disabilities. Departments and agencies should coordinate and collaborate with each other and with public and private stakeholders to ensure that existing and new sources of medical and health-related data are handled in the best interest of patients with regards to security, interoperability, privacy, accessibility, and portability.

Veteran Health and Wellness: The *President's Roadmap to Empower Veterans and End a National Tragedy of Suicide* (PREVENTS)[10] directs research on the social determinants of health and underlying risk factors to prevent veteran suicide. Departments and agencies should identify R&D investments, consistent with the *Executive Order on a National Roadmap to Empower Veterans and End Suicide*, that focus on cohesive, cross-agency efforts; leverage data sharing and integration to derive new insights into brain health and suicide from existing studies or data sets; and seek opportunities for immediate knowledge translation and real-world application.

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[10] Executive Order on a National Roadmap to Empower Veterans and End Suicide. https://www.whitehouse.gov/presidential-actions/executive-order-national-roadmap-empower-veterans-end-suicide/

Bioeconomy: The American Bioeconomy represents the infrastructure, innovation, products, technology, and data derived from biologically-related processes and science that drive economic growth, promote health, and increase public benefit. The increasing economic value and public benefits derived from the research, innovation, and applications in the biological and agricultural sciences need to be better measured, promoted, and safeguarded. Departments and agencies should prioritize evidence-based standards and research to rapidly establish microorganism, plant, and animal safety and efficacy for products developed using gene editing, to better accelerate biotechnology product adoption and socially responsible use. Additionally, departments and agencies should focus on R&D that enables biotechnology, omics, scientific collections, biosecurity, and data analytics to drive economic growth across multiple sectors including healthcare, pharmaceuticals, manufacturing, and agriculture.

5. American Space Exploration and Commercialization

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 and utilizing the Moon as a proving-ground for a future human mission to Mars.

Departments and agencies should prioritize in-situ resource utilization on the Moon and Mars, cryogenic fuel storage and management, in-space manufacturing and assembly, and advanced space-related power and propulsion capabilities. 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 and Leverage a Diverse, Highly Skilled American Workforce

The Trump Administration's 2018 report, *Charting a Course for Success: America's Strategy for STEM Education* (STEM Strategy), articulates a vision that "all Americans will have lifelong access to high quality STEM education and the United States will be the global leader in STEM literacy, innovation, and employment."[11] Achieving this vision depends on a multisector seamless STEM education and training ecosystem that can meet the needs of all Americans from all backgrounds and ZIP codes and can adapt to the changing, and often growing, demands for STEM knowledge and skills in both the workplace and in everyday life.

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[11] NSTC. "Charting A Course For Success: America's Strategy for STEM Education." https://www.whitehouse.gov/wp-content/uploads/2018/12/STEM-Education-Strategic-Plan-2018.pdf.

Departments and agencies should prioritize efforts to build strong foundations for STEM literacy, to increase diversity, equity, and inclusion in STEM, and to prepare the STEM workforce, including college-educated STEM workers and those working in skilled trades that do not require a four-year degree.

In addition, relevant departments and agencies should identify and implement strategies to: help build R&D capacity at institutions that serve high proportions of underrepresented or underserved groups, such as Historically Black Colleges and Universities (HBCUs), tribal colleges and universities, and Hispanic Serving Institutions; foster collaboration and coordination among higher education institutions, the private sector, and nonprofits to meet the objectives described in the STEM Strategy and the 2017 *Executive Order on The White House Initiative to Promote Excellence and Innovation at Historically Black Colleges and Universities*;[12] facilitate the advancement of early career R&D professionals; and assess the capabilities of their own workforces, and leverage resources that provide upskilling and entrepreneurial training.

2. Create and Support Research Environments that Reflect American Values

To advance S&T progress and ensure maximum return on taxpayer investment in R&D, the laboratory, the factory, the field, and any other setting where R&D is performed must welcome all individuals without prejudice and enable them to work safely, efficiently, ethically, and with respect, consistent with the American values of free inquiry, competition, openness, and fairness. Four high-priority areas related to research environments require significant attention:

- Reducing administrative burdens on Federally-funded research;[13]
- Improving rigor and integrity in research;
- Creating safe and inclusive research environments; and
- Protecting American research assets.

Departments and agencies should ensure that their R&D investments promote intra- and extra-mural research environments that address these four actions and rapidly improve or eliminate programs and activities that do not; and actively coordinate and collaborate with other R&D departments and agencies, via the NSTC Joint Committee on the Research Environment (JCORE), to ensure that R&D investments and policies are aligned with the four priority areas.[14]

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[12] Established by the 2017 Executive Order, The White House Initiative on HBCUs is charged with working with "agencies, private-sector employers, educational associations, philanthropic organizations, and other partners to increase the capacity of HBCUs to provide the highest-quality education to an increasing number of students." https://www.whitehouse.gov/presidential-actions/presidential-executive-order-white-house-initiative-promote-excellence-innovation-historically-black-colleges-universities/.

[13] In addition, the PMA CAP Goal 8—"Results-Oriented Accountability for Grants"—is tackling how to streamline burdensome administrative requirements associated with all federal grant programs and move towards the current compliance paradigm towards demonstrating results. These efforts include attention to R&D grants and the burdens upon the research community.

[14] 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.

3. Support Transformative Research of High Risk and Potentially High Reward

Many of the greatest advances in S&T—for example, the first direct detection of gravitational waves—can be traced to Federal support of R&D that is intellectually challenging but has the potential to transform society in profound and positive ways. In order to remain the world leader in S&T, America must continue to support bold thinking and potentially transformative research ideas.

Departments and agencies should support risk taking in their R&D investments and within the communities they support, and they should ensure that review processes fully consider the possible rewards, risks, and benefits of failure for potentially transformative research. Departments and agencies should describe how their investments support transformative research, and the impact these investments could have on American prosperity and security.

4. Leverage the Power of Data

The President's Management Agenda (PMA) Cross-Agency Priority (CAP) Goal 2, "Leveraging Data as a Strategic Asset,"[15] 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. Priorities include improving data accessibility and security, leveraging AI and other emerging technologies, and building a data-skilled workforce. Departments and agencies should coordinate and collaborate with each other and with the private sector and nonprofits to leverage data and data tools, consistent with all applicable laws and regulations governing data use and sharing.

5. Build, Strengthen, and Expand Strategic Multisector Partnerships

Partnerships between and among R&D departments and agencies, academic institutions, established and startup businesses, nonprofit institutions, and others involved in the U.S. S&T enterprise are instrumental to building and leveraging our Nation's innovation capacity and lie at the core of success for the Second Bold Era of S&T.

Departments and agencies should prioritize investments and policies that facilitate or strengthen multisector partnerships, including partnerships that engage institutions seeking to build S&T capacity, such as R2 ("high research activity") institutions, HBCUs, and community

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[15] The Federal Data Strategy. http://strategy.data.gov

colleges; advance regional collaboration for innovation economies, such as those in Opportunity Zones; support research infrastructure; and further the objective of CAP Goal 14 to "Improve Transfer of Federally-Funded Technologies from Lab-to-Market."[16] Departments and agencies should work together to leverage existing and create new partnerships, share best practices, data, user facilities, and other resources to the extent possible. Departments and agencies should define measures of success and describe how relevant R&D investments improve the number, variety, and quality of partnerships. They should also consider methods to reduce regulatory and administrative barriers and align incentives to facilitate multisector engagement.

[16] Improve Transfer of Federally-Funded Technologies from Lab-to-Market. https://www.performance.gov/CAP/lab-to-market/