

V.3 DRAFT
FINAL REPORT –
BLUEPRINTS FOR
ACTION
PART II

National Security Commission on Artificial Intelligence

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The following Blueprints for Action cover Part II of NSCAI’s Final Report. Part II, “Winning the Technology Competition,” (Chapters 9-16) outlines AI’s role in a broader technology competition, and recommends actions the government must take to promote AI innovation to improve all facets of national competitiveness and protect critical U.S. advantages. These Blueprints for Action complement the Commission’s Final Report and mirror its organizational structure.

Building upon the top-line recommendations in the Commission’s Final Report, the Blueprints for Action serve as more detailed roadmaps for Executive and Legislative branch actions to retain America’s AI leadership position. The Blueprints for Action identify who should take a particular action—Congress, the White House, or an executive branch department or agency. The Commission provides estimated increases in funding or appropriations as part of its recommendations. All recommendations that include funding figures should be considered estimates for consideration by Congress and/or the Executive Branch.

Chapter 9: A Strategy for Competition and Cooperation

Blueprint for Action

The United States should advance a comprehensive policy on China that promotes and protects a rules-based international order. By investing in U.S. competitiveness and resilience at home, safeguarding critical technologies, and deepening coordination with allies and partners, the United States can pursue cooperation with China—where it is in the national interest and from a position of strength. Properly sequenced and resourced, such a strategy would generate solutions to global challenges and leverage formal diplomatic dialogue to address critical issues around emerging technology.

Recommendation: Establish a high-level U.S.-China Comprehensive Science and Technology Dialogue (CSTD)

The United States should establish a regular, high-level technology dialogue with China that benefits the American people, remains faithful to our allies, and presses China to abide by international rules and norms. The dialogue should focus on challenges presented by emerging technologies—to include AI, biotechnology, and other technologies as agreed by both sides. The CSTD should have two overarching objectives:

- Identify targeted areas of cooperation on emerging technologies to solve global challenges such as climate change, public health, and natural disasters; and
- Provide a forum to air a discrete set of concerns or friction points around specific uses of emerging technologies while building relationships and establishing process between the two nations.

The United States should be clear-eyed that the dialogue will not solve all our differences with China. The CSTD should be results-oriented, and it should achieve concrete outcomes for the American people.

Actions for the White House and the Department of State:

- **Establish the CSTD.**
 - Emerging technologies play an instrumental role in the economic, social, and security dynamics between the United States and China. Therefore, the CSTD should be established as part of a comprehensive strategy toward China that mobilizes democratic allies and partners in support of a rules-based international order.
 - The Department of State—in close coordination with the Office of Science and Technology Policy—should lead the CSTD.
 - The Department of State should build a process that is result oriented and aims to address challenges and opportunities in the current relationship between the United States and China related to the emerging technologies. For example:
 1. The CSTD should explore collaborative technological solutions to global challenges (e.g., climate change, healthcare and biodata, food safety and

- security, and natural disasters).
2. The CSTD should identify areas of current challenges related to emerging technologies (e.g., data sharing and privacy, supply chain risk management, international standards and norms, and intellectual property) and develop a clear roadmap with milestones to address these issues.
 - The CSTD should initiate personnel exchanges and data sharing frameworks to support and foster identified research projects with reciprocal access to information that can lead to concrete results.
 - The United States should identify leads for each of these topics (e.g., the Department of Energy, the National Oceanic and Atmospheric Administration, and the U.S. Special Presidential Envoy for Climate for climate change, the National Institutes of Health for healthcare, the Food and Drug Administration for food safety, and the Department of Defense and U.S. Agency for International Development for natural disasters).
- *Relation to strategic dialogue.* On a separate track from this CSTD, the Commission has recommended the United States and Chinese governments convene a strategic security dialogue (SSD) focused on eliminating misunderstandings and misperceptions on key strategic issues and threats, and reducing the likelihood of inadvertent escalation. China has resisted U.S. attempts to create such a dialogue for nearly a decade, but its creation has never been more critical. The Commission's vision regarding the role of the SSD is explored in greater detail in Chapter 4 of this report.
 - This dialogue should be the primary forum for discussions regarding practices surrounding AI-enabled and autonomous weapon systems, and should include discussions on testing, doctrine, and use, and potentially the exploration of practical concrete confidence building measures to mitigate risks.
 - It is important to separate the SSD from the CSTD to ensure discussions related to conflict escalation and crisis stability are insulated from political forces which influence the broader U.S.-China bilateral relationship.

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Chapter 9 Annex: A Strategy for Competition and Cooperation

Draft Executive Order Establishing the Technology Competitiveness Council

By the authority vested in me as President by the Constitution and laws of the United States of America, and in order to provide a coordinated process for developing technology policy and a national technology strategy and for monitoring its implementation, it is hereby ordered as follows:

Section 1. Policy. The national security, economic competitiveness, and domestic prosperity of the United States require a comprehensive and coordinated approach by the Federal Government to ensure long-term U.S. leadership across the entire suite of critical and emerging technologies. To achieve this objective, this order establishes a Technology Competitiveness Council to develop a National Technology Strategy and to coordinate policies regarding critical and emerging technologies across the Federal Government.

Sec. 2. The Technology Competitiveness Council.

(a) *Establishment.* There is established a Technology Competitiveness Council (Council).

(b) *Membership.* The Council shall be composed of the following members:

- (i) the Vice President, who shall be Chair of the Council;
- (ii) the Secretary of State;
- (iii) the Secretary of the Treasury;
- (iv) the Secretary of Defense;
- (v) the Attorney General;
- (vi) the Secretary of Commerce;
- (vii) the Secretary of Energy;
- (viii) the Secretary of Homeland Security;
- (ix) the Director of the Office of Management and Budget;
- (x) the Assistant to the President for Technology Competitiveness;
- (xi) the Assistant to the President for National Security Affairs;
- (xii) the Assistant to the President for Science and Technology;
- (xiii) the Assistant to the President for Economic Policy;

(xiv) the Assistant to the President for Domestic Policy;

(xv) the United States Trade Representative;

(xvi) the Chairman of the Joint Chiefs of Staff; and

(xvii) the heads of other executive departments and agencies and other senior officials within the Executive Office of the President, as determined by the Chair.

A member of the Council may designate, to perform the Council functions of the member, a senior-level official who is part of the member's department, agency, or office, and who is a full-time officer or employee of the Federal Government.

(c) *Responsibilities of the Chair.*

(i) The Chair, or upon his or her direction, the Assistant to the President for Technology Competitiveness, shall convene and preside over meetings of the Council and shall determine the agenda for the Council.

(ii) The Chair shall authorize the establishment of such committees of the Council, including an executive committee, and of such working groups, composed of senior designees of the Council members and of other officials invited to participate in Council meetings, as he or she deems necessary or appropriate for the efficient conduct of Council functions.

(iii) The Chair shall report to the President on the activities and recommendations of the Council. The Chair shall advise the Council as appropriate regarding the President's directions with respect to the Council's activities and national technology policy generally.

(d) *Administration.*

(i) The Council shall have a staff, headed by the Assistant to the President for Technology Competitiveness.

(ii) The Office of Administration in the Executive Office of the President shall provide the Council with such personnel, funding, and administrative support, to the extent permitted by law and subject to the availability of appropriations, as directed by the Chair or upon the Chair's direction, the Assistant to the President for Technology Competitiveness, to carry out the provisions of this order.

(iii) To the extent practicable and permitted by law, including the Economy Act, and within existing appropriations, agencies serving on the Council shall make resources, including, but not limited to, personnel and office support, available to the Council as

reasonably requested by the Chair or, upon the Chair's direction, the Assistant to the President for Technology Competitiveness.

(iv) The heads of agencies shall provide, as appropriate and to the extent permitted by law, such assistance and information to the Council as the Chair may request to implement this order.

(v) Members of the Council shall ensure that their departments and agencies cooperate with the Council and provide such assistance, information, and advice to the Council as the Council may request, to the extent permitted by law.

(vi) The creation and operation of the Council shall not interfere with existing lines of authority and responsibilities in the departments and agencies.

(vii) On technology policy and strategy matters relating primarily to national security, the Council shall coordinate with the National Security Council (NSC) through the Deputy National Security Advisor for Cyber and Emerging Technology to create policies and procedures for the Council that respect the responsibilities and authorities of the NSC under existing law.

Sec. 3. Functions of the Council. The Council shall:

(a) develop recommendations for the President on U.S. technology competitiveness and technology-related issues, advise and assist the President in development and implementation of national technology policy and strategy, and perform such other duties as the President may prescribe;

(b) develop and oversee the implementation of a National Technology Strategy as required by section 4 of this order;

(c) serve as a forum for balancing national security, economic, and technology considerations of U.S. departments and agencies as they pertain to technology research, development, commercial interests, and national security applications;

(d) coordinate policies across U.S. departments and agencies related to U.S. competitiveness in critical and emerging technologies and ensure that policies designed to promote U.S. leadership and protect existing competitive advantages are integrated and mutually-reinforcing; and

(e) synchronize budgets and strategies, in consultation with the Director of the Office of Management and Budget, in accordance with the National Technology Strategy.

Sec. 4. National Technology Strategy. It is the policy of the United States to retain leadership in critical and emerging technologies essential to U.S. national security and economic prosperity. Within one year of the date of this order, and annually thereafter, the Council shall submit to the President a National Technology Strategy to containing the following elements:

- (a) an assessment of the U.S. Government's efforts to preserve U.S. leadership in key emerging technologies and prevent U.S. strategic competitors from leveraging advanced technologies to gain strategic military or economic advantages over the United States;
- (b) a review of existing U.S. Government technology policy, including long-range goals;
- (c) an analysis of technology trends and assessment of the relative competitiveness of U.S. technology sectors in relation to strategic competitors;
- (d) identification of sectors critical for the long-term resilience of U.S. innovation leadership across design, manufacturing, supply chains, and markets;
- (e) recommendations for domestic policy incentives to sustain an innovation economy and develop specific, high-cost sectors necessary for long-term national security ends;
- (f) recommendations for policies to protect U.S. and allied leadership in critical areas through targeted export controls and investment screening and counterintelligence activities;
- (g) identification of priority domestic research and development areas critical to national security, necessary to sustain U.S. leadership, and direct funding to fill gaps in basic and applied research where the private sector does not focus;
- (h) recommendations for talent programs to grow U.S. talent in key critical and emerging technologies and enhance the ability of the Federal Government to recruit and retain individuals with critical skills into Federal service; and
- (i) methods to foster the development of international partnerships to reinforce domestic policy actions, build new markets, engage in collaborative research, and create an international environment that reflects U.S. values and protects U.S. interests.

Sec. 5. Advisory Committee on Technology Competitiveness.

- (a) There is established an Advisory Committee on Technology Competitiveness (Committee) to provide advice and recommendations to the Council and matters within the scope of the Council's responsibilities.
- (b) The Committee shall include the Assistant to the President for Technology Competitiveness, and not more than 16 additional members appointed by the President. The additional members shall include distinguished individuals from sectors outside of the Federal Government. They shall have diverse backgrounds and expertise in national security, economic competitiveness, and critical and emerging technologies relevant to the National Technology Strategy. The Assistant to the President for Technology Competitiveness, along with one non-Federal member of the Committee, shall serve as Co-Chairs. Members of the Committee shall serve without any compensation for their work on the Committee, but may receive travel

expenses, including per diem in lieu of subsistence, as authorized by law for persons serving intermittently in the government service (5 U.S.C. 5701-5707).

(c) The Committee shall meet as directed by the Co-Chairs of the Council and shall provide advice or work product solely for use by the Council in the performance of its duties under this order.

(d) The Office of Administration in the Executive Office of the President shall provide such funding and administrative and technical support as the Committee may require.

(e) The Committee shall terminate 2 years from the date of this order unless extended by the President.

Sec. 6. General Provisions.

(a) If any provision of this order or the application of such provision is held to be invalid, the remainder of this order and other dissimilar applications of such provision shall not be affected.

(b) This order is not intended to, and does not, create any right or benefit, substantive or procedural, enforceable at law or in equity by any party against the United States, its departments, agencies, or entities, its officers, employees, or agents, or any other person.

(c) Nothing in this order shall be construed to impair or otherwise affect:

(i) the authority granted by law to an executive department or agency, or the head thereof; or

(ii) the functions of the Director of the Office of Management and Budget relating to budgetary, administrative, or legislative proposals.

(d) This order shall be implemented consistent with applicable law and subject to the availability of appropriations.

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Chapter 10: The Talent Competition Blueprint for Action

The United States must dramatically invest in its artificial intelligence (AI) talent pipelines in order to remain at the forefront of AI now and into the future. It is imperative that the United States strategically invest in science, technology, engineering, and mathematics (STEM) education at all levels and improve the immigration system to allow for more AI talent to enter and remain in the United States. Therefore, this Blueprint for Action is broadly organized into two broad categories of recommendations for strengthening the U.S. talent pipeline: the U.S. education system and immigration.

Talent Pipeline: U.S. Education System

Investments in STEM education are a necessary part of increasing American national power and improving national security. This requires the United States to reform its education system to produce both a higher quality and quantity of graduates.

Recommendation: Pass a New National Defense Education Act

In response to the Soviet launch of Sputnik in 1957, the United States passed the National Defense Education Act (NDEA) in 1958 to extend U.S. leadership in education and innovation.¹ The NDEA promoted the importance of science, mathematics, and foreign languages for students, authorizing over one billion dollars toward decreasing student loans, funding for education at all levels, and funding for graduate fellowships. Many students were able to attend college because of this bill. 3.6 million students attended college in 1960; by 1970 it was 7.5 million.² This act helped America win the Space Race and accelerated our ability to innovate, and is widely regarded as one of the most successful pieces of education legislation in U.S. history.

Now is the time for a new National Defense Education Act (NDEA). The NDEA greatly increased the number of Americans with a college degree, expanded the number of math and science teachers to meet the demand of the K-12 educators after the post-war baby boom, and was focused on defense-centric fields, particularly a deficiency in mathematicians. The impacts of federal spending on higher education today are echoes of the investments made in the late 1950s by the Eisenhower administration. The United States needs a second National Defense Education Act (NDEA II) in order to address the current digital talent gap and prevent the United States from falling behind in the race for AI and STEM talent.

Actions for Congress:

- **Increase Funding for STEM and AI-Focused After-School Programs**

¹ Pub. L. 85-865.

² *Sputnik Spurs Passage of the National Defense Education Act*, U.S. Senate (last accessed Jan. 29, 2021), https://www.senate.gov/artandhistory/history/minute/Sputnik_Spurs_Passage_of_National_Defense_Education_Act.htm#:~:text=The%20National%20Defense%20Education%20Act%20of%201958%20became%20one%20of,and%20private%20colleges%20and%20universities.

- STEM and AI-focused after-school learning programs expose students to STEM and AI related programs beyond normal school hours. The length of the school day limits teachers' ability to cover a myriad of topics during the school day. American elementary school students are exposed to an average of 20 minutes of science and 60 minutes of math during the school day.³ Given the short amount of time that teachers are able to spend on STEM in their classrooms, some school districts have begun to offer after school programs that expose students to STEM in a less structured environment. More time spent studying STEM topics helps students' test scores and for those who are underrepresented in STEM fields, federal funding for after school programs will increase students' accessibility to quality educational tools.⁴ Appropriations for after-school programs should favor applications that are jointly submitted by a local educational agency and a community-based organization or other public or private entity as a way to defray costs and encourage community engagement.
- **Increase funding for STEM and AI-Focused Summer Learning Programs**
 - STEM and AI-focused summer learning programs will encourage students to engage in STEM and AI activities during the months that students are typically unengaged and experience learning loss. The 21st Century Community Learning Centers Act is an example of a program that funds “academic enrichment opportunities during non-school hours for children, particularly students who attend high-poverty and low-performing schools,” that has proven, positive results.⁵ Much like the after-school initiative, priority should be given to those applications that are jointly submitted by a local educational agency and a community-based organization or other public or private entity.
- **Allocate Funds for K-12 STEM Teacher Recruitment, Retention, and Training**
 - Teachers are an integral part of the learning experience for STEM subjects. One inequity is the lack of teachers with the requisite proficiency in STEM. Evidence shows that STEM teacher training for current teachers is sporadic, ineffective, and not effective in addressing the specific needs of individual students.⁶ Moreover, recruiting high-quality K-12 teachers with STEM experience and proficiency is difficult. This is particularly concerning as teachers are one of the most influential

³ *Highlights From the 2018 NSSME+*, The National Survey of Science and Mathematics Education at 17 (Jan. 2019), <http://horizon-research.com/NSSME/wp-content/uploads/2019/01/Highlights-from-2018-NSSME.pdf>. Additionally, almost half of Americans believe that students don't spend enough time during school hours on STEM subjects. Cary Funk & Kim Parker, *Most Americans Evaluate STEM Education as Middling Compared with Other Developed Nations*, Pew Research Center (Jan. 9, 2018), <https://www.pewsocialtrends.org/2018/01/09/5-most-americans-evaluate-stem-education-as-middling-compared-with-other-developed-nations/>.

⁴ Kristen A. Malzahn, et al., *Are All Students Getting Equal Access to High-Quality Mathematics Education? Data From the 2018 NSSME+*, The National Survey of Science and Mathematics Education at 15 (Feb. 2020), <http://horizon-research.com/NSSME/wp-content/uploads/2020/02/Math-Equity-Report.pdf>.

⁵ *21st Century Learning Centers*, Department of Education (last accessed Jan. 1, 2021), <https://www2.ed.gov/programs/21stcclc/index.html>.

⁶ *Successful K-12 STEM Education*, National Research Council at 20-21 (2011), <https://www.nap.edu/catalog/13158/successful-k-12-stem-education-identifying-effective-approaches-in-science>.

aspects of school, having two to three times the impact of other components, such as leadership and school services.⁷ As the world continues to integrate technology into education, teachers must be taught how to use this technology as well as how to teach students the critical foundations and basic functions that come with it.⁸ Support should be given to school districts to create and execute teacher training in AI concepts, techniques, and curriculum design, with preference given to professional development courses that count against continuing education requirements for teacher certification.

- **Direct and Fund the National Science Foundation to Create STEM Scholarships and Fellowships**

- We recommend the NSF create 25,000 STEM undergraduate scholarships, 5,000 STEM Ph.D. fellowships, and 500 postdoctoral positions over five years to increase the number and quality of STEM and AI practitioners that will reach the job market in a few years.⁹ Growing the nationwide STEM talent pool in high-demand areas requires a pipeline of students who have studied relevant STEM coursework during their undergraduate careers. Between 2000 and 2017, the share of STEM bachelor's degrees earned—as a percentage of total bachelor's degrees earned in the US—rose from 32% to 35%.¹⁰ The sharpest recent increases were among computer science and engineering majors.¹¹ For AI specifically, a degree in cognitive science or computer science with concentrations in AI or machine learning (ML) can pave the way for future careers in AI research or practice. AI is rarely offered as a major at the undergraduate level. Instead, universities offer standalone courses, a sequence of AI courses, or the option to study a technical major with a concentration in AI. Until a major in AI is more universally offered at U.S. universities, STEM scholarships will increase the number of individuals with the skills necessary to work on AI.
- Scholarship and fellowship recipients should receive full tuition, room and board. Undergraduate recipients should receive a stipend of \$40,000 a year, and graduate recipients should receive a stipend of \$70,000 a year.¹² Combined with postdoctoral positions, this will bring the total cost to \$7.2 billion over five

⁷ Isaac M. Opper, *Teachers Matter: Understanding Teachers' Impact on Student Achievement*, RAND (2019), <https://www.rand.org/education-and-labor/projects/measuring-teacher-effectiveness/teachers-matter.html>.

⁸ Amy Johnson, et. al. *Challenges and Solutions When Using Technologies in the Classroom*, Adaptive Educational Technologies for Literacy Instruction (2016), <https://files.eric.ed.gov/fulltext/ED577147.pdf>.

⁹ James Manyika & William H. McRaven, *Innovation and National Security: Keeping our Edge*, Council on Foreign Relations (Sept. 2019), <https://www.cfr.org/report/keeping-our-edge/recommendations/>

¹⁰ Josh Trapani & Katherine Hale, *Trends in Undergraduate and Graduate S&E Degree Awards*, National Science Foundation, Figure 2-6 (Sept. 4, 2019), <https://nces.nsf.gov/pubs/nsb20197/trends-in-undergraduate-and-graduate-s-e-degree-awards>.

¹¹ Josh Trapani & Katherine Hale, *Trends in Undergraduate and Graduate S&E Degree Awards*, National Science Foundation at Figure 2-6 (Sept. 4, 2019), <https://nces.nsf.gov/pubs/nsb20197/trends-in-undergraduate-and-graduate-s-e-degree-awards>

¹² The \$70,000 stipend is intended to incentivize American students to pursue graduate research, rather than transitioning to the private sector directly after completing their undergraduate degree. Research has shown that higher stipends increase the number and quality of program applicants, likely “attract[ing] some potentially outstanding science and engineering students who would otherwise choose other careers.” See https://users.nber.org/~sewp/Freeman_NSFstip_Proceedings.pdf.

years.¹³

- **Add Elements of Computational Thinking and Statistics to Student Testing**
 - Computational thinking and statistics are vital for students to understand how AI works.¹⁴ As interdisciplinary fields, the use of computational thinking and statistics within AI can be found at all stages of discovery, from developing and planning studies to assessing the results. Critical thinking along with problem solving are vital skills taught in statistics. Unfortunately, the majority of high schools in America do not require testing for skills related to computational thinking for graduation.¹⁵ There is no way to comprehensively measure U.S. students' overall abilities or aptitude for skills related to computational thinking and statistics. Students are taught what is needed to pass exams. Compared to other countries, many of which have statistics in their curriculum, the United States ranks low in math.¹⁶ Standardized tests, required at the state level through the Every Student Succeeds Act (ESSA),¹⁷ are a common tool used by researchers and educators to measure a student's abilities and gain an understanding of their knowledge and skill set. By including subjects critical for computational thinking and statistics in standardized testing at the state level, the United States can gain a better understanding of student's capabilities and work to implement curriculum and lessons focused more on computational thinking and statistics in order to ensure students success.

Recommendation: Require statistics in middle school and computer science principles in high school.

Actions for State Legislatures:

- Require statistics as a required course in middle school and computer science principles in high school. Many fundamental concepts in AI, ML, and their subfields are applied statistics in disguise.¹⁸ The techniques and algorithms used are heavily based in statistical methods, such as cluster analysis and model selection. Statistics and computer science principles are needed to prepare students for AI courses, concentrations, and internships. Providing training in statistics starting in middle school will better prepare students for

¹³ Based on the Commission staff's research, the Commission calculates this total allotting an estimated \$175,000 per postdoctoral fellow per year.

¹⁴ Computational thinking can be defined as "a way of solving problems, designing systems, and understanding human behavior that draws on concepts fundamental to computer science." Center for Computational Thinking at Carnegie Mellon (last accessed Feb. 8, 2021), <http://www.cs.cmu.edu/~CompThink/>. Some current subjects relevant to computational thinking include computer science, coding, and statistics.

¹⁵ See *50 State Comparison: High-School Graduation Requirements*, Education Commission of the States, (Feb. 2019), <https://internal-search.ecs.org/comparisons/high-school-graduation-requirements-01>. As shown in this 50 state comparison, unlike algebra, statistics is rarely listed as a graduation requirement. See id.

¹⁶ Erin Richards, *Math Scores Stink in America. Other Countries Teach it Differently and See Higher Achievement.*, USA Today (Feb. 29, 2020), <https://www.usatoday.com/story/news/education/2020/02/28/math-scores-high-school-lessons-freakonomics-pisa-algebra-geometry/4835742002/>.

¹⁷ Pub. L. 114-95, 114th Cong. (2015).

¹⁸ Statistics, including foundations of probability, hypothesis testing, expected utility, decision analysis, and causality, and introductions to topics in the broader data sciences, such as basics of pattern recognition and machine learning.

the increasingly advanced analytic techniques in demand for AI and STEM careers. Similarly, currently just 47% of U.S. high schools offer computer science coursework.¹⁹ This is much higher than just a decade ago, thanks to nationally-organized initiatives, but this still leaves many high schools without CS education. Moreover, adoption has been piecemeal and curriculum depth varies widely. Therefore, state action is needed. On their own, neither statistics nor computer science are sufficient to teach students the concepts needed to understand AI. Having both allows students to experience the critical bases that must be covered early on in order to prepare students for a technological career. Simple math such as basic probability and summarizing numerical data is applying concepts of statistics and computer science.

Talent Pipeline: Immigration

Immigration reform is imperative for strengthening the U.S. talent pipeline, particularly given the significant benefits the United States experiences due to highly skilled immigration. Therefore, the United States must pursue reforms to accelerate highly skilled immigration to and retainment of international students within the United States.

Recommendation: Pass a National Security Immigration Act

The following recommendations are intended to help the United States lead the world's development and implementation of AI by gaining a decisive majority of a critical and limited resource: AI talent. The recommendations will improve the United States' ability to attract talent to the United States, and just as importantly, away from competing countries.

The United States needs to take bold steps to ensure it wins the competition for international talent for years to come. Such steps should ensure our immigration system attracts students, technical experts, and entrepreneurs; grants stability while they continue to contribute to the American economy and research environment; and retains students, entrepreneurs, and experts rather than sending them home or to competing countries. The best way to accomplish these goals and to send a clear message to AI and STEM talent around the world is to pass a National Security Immigration Act that specifically helps STEM talent remain in the United States, reduces the overall burden of the citizenship process, and creates specific paths for entrepreneurs.

Recommendation: Pass a National Security Immigration Act

1) Grant Green Cards to All Students Graduating with STEM PhDs from Accredited American Universities

This would issue an incredibly clear message to talented young people around the world that they are welcome in the United States, and would ease their transition to American citizenship. It is a very aggressive maneuver to gain a larger share of the world's STEM talent.

¹⁹ *2020 State of Computer Science Education: Illuminating Disparities*, Code.org Advocacy Coalition, Computer Science Teachers Association & Expanding Computing Education Pathways Alliance (2020), https://advocacy.code.org/2020_state_of_cs.pdf.

Such a proposal is admittedly bold, but the benefits of attracting vetted, top-tier talent outweigh the risks. Bold measures are needed to preserve America's advantages in STEM fields today and to ensure we out-innovate and out-perform competitors in the future.²⁰ Few other proposals are significant enough to make a dramatic difference in the competition for talent, or to force China into a dilemma on their domestic front. It is also noteworthy that similar proposals have received bipartisan support in the past.²¹

Actions for Congress:

- **Amend 8 U.S.C. 1151(b)(1) to grant lawful permanent residence to any foreign national who:**
 - Graduates from an accredited United States institution of higher education with a doctoral degree in a field related to science, technology, engineering, or mathematics in a residential or mixed residential and distance program;
 - Has a job offer in a field related to science, technology, engineering, or mathematics; and
 - Does not pose a national security risk to the United States.
- **Vetting for national security concerns should be enabled by the FBI and Intelligence Community.**
- **Graduates granted lawful permanent residence through this program should not count against overall or country of origin green card caps.**

2) Double the Number of Employment Based Green Cards

Whether one aims for the United States to achieve AI dominance, grow gross domestic product (GDP), stimulate job growth, reduce government deficits, or bolster the solvency of the U.S. Social Security program, the most straightforward solution is the same: increase the number of highly skilled permanent residents. Under the current system, employment-based green cards are scarce: 140,000 per year, fewer than half of which go to the principal worker.²² This leaves many highly skilled workers unable to gain permanent residency, and unable to transfer jobs or negotiate with employers as effectively as domestic workers. If underpaid, these workers cannot leave their job or bargain for better wages without risking revocation of the employer's green card sponsorship or even firing and forced departure from the United States. This decreases the appeal of joining the American workforce.

²⁰ According to the National Science Foundation (NSF), in 2018, 179,500 undergraduate and 233,600 graduate international students were enrolled in science and engineering programs in the United States. Beethika Kahn, et al., *The State of U.S. Science and Engineering 2020*, NSF (Jan. 15, 2020), <https://ncses.nsf.gov/pubs/nsb20201/u-s-and-global-education#degree-awards>. It should not be assumed that all of these students would meet the listed criteria.

²¹ A 2013 Senate-passed bill would have exempted all PhD and master's STEM degree holders (U.S. graduates) and all PhD holders in any field (worldwide graduates) from green card caps. Madeleine Sumption & Claire Bergeron, *Remaking the U.S. Green Card System: Legal Immigration under the Border Security, Economic Opportunity, and Immigration Modernization Act of 2013*, Migration Policy Institute 2, 8 (June 2013), <https://www.migrationpolicy.org/research/remaking-us-green-card-system-legal-immigration-economic-opportunity>.

²² William Kandel, *The Employment-Based Immigrant Backlog*, Congressional Research Service at 4-5 (Mar. 26, 2020), <https://fas.org/sgp/crs/homesecc/R46291.pdf>.

The H-1B system is problematic for most employers, as well, with a consistently oversubscribed “lottery” of 85,000 visas each year (of which 20,000 are reserved for advanced degree holders from U.S. universities).²³ To reduce the backlog of highly skilled workers, the United States should double the number of employment based green cards, with an emphasis on permanent residency for STEM and AI-related fields. If it were easier for U.S. employers to sponsor global talent for a green card as opposed to an H-1B visa, the H-1B program could then serve its originally intended function, as a vehicle for truly temporary high-skill work needs.

Action for Congress:

- **Amend 8 U.S.C. 1151(d)(1)(A) by changing “140,000, plus” to “280,000, plus.”**

3) Create an Entrepreneur Visa

International doctoral students are more likely to want to found a company or become an employee at a startup than their native peers, but, in practice, are less likely to pursue those paths. One reason is the constraints of the H-1B visa system.²⁴ Similarly, immigrant entrepreneurs without the capital to use the EB-5 route to permanent residency are forced to use other visas that are designed for academics and workers in existing companies, not entrepreneurs.²⁵ All of these issues make the United States less attractive for international talent, and, just as importantly, reduce the ability of startups and other small companies, the main source of new jobs for Americans, to hire highly skilled immigrants that have been shown to improve the odds the business will succeed.

Actions for Congress:

- **Create an entrepreneur visa. This visa should serve as an alternative to employee-sponsored, investor, or student visas, and should instead target promising potential founders. Legislation should:**
 - Define an entrepreneur as an alien whose organization and operation of a business would provide significant public benefit to the United States if allowed to stay in the country for a limited trial period to grow a company.
 - Prioritize entrepreneurs active in high-priority fields such as AI, or in fields that use AI for other applications, such as agriculture. The National Science Foundation should update the list of high priority fields every three years.
 - Use capital capture as a screening criterion for entrepreneurs.
 - Emphasize job creation for Americans—potentially emphasizing underserved regions or areas with high unemployment—as a core factor in the assessment of significant public benefit.

²³ *H-1B Fiscal Year (FY) 2021 Cap Season*, U.S. Citizenship & Immigration Services (last accessed Jan. 4, 2021), <https://www.uscis.gov/working-in-the-united-states/temporary-workers/h-1b-specialty-occupations-and-fashion-models/h-1b-fiscal-year-fy-2021-cap-season>.

²⁴ Michael Roach, et al., *Are Foreign STEM PhDs More Entrepreneurial? Entrepreneurial Characteristics, Preferences and Employment Outcomes of Native and Foreign Science & Engineering PhD Students*, National Bureau of Economic Research at 12 (2019), <https://www.nber.org/papers/w26225>.

²⁵ William R. Kerr, *Global Talent and U.S. Immigration Policy: Working Paper 20-107*, Harvard Business School at 14 (2020), https://www.hbs.edu/faculty/Publication%20Files/20-107_0967f1ab-1d23-4d54-b5a1-c884234d9b31.pdf.

4) Create an Emerging and Disruptive Technology Visa

A new nonimmigrant visa designed to attract top technology talent in critical fields would allow universities and businesses that work on AI and other emerging technologies access to a greater pool of talent necessary to create cutting-edge research. It would also respond more flexibly to labor markets demands as new technologies emerge. The effect would be to “revitalize our country’s research ecosystem, empower our country’s innovation economy, and ensure that the United States remains a world superpower in the coming decades.”²⁶

Action for Congress:

- **Create an emerging and disruptive technology visa that:**
 - Requires the National Science Foundation to identify critical emerging and disruptive technologies every three years;
 - Allows students, researchers, entrepreneurs, and technologists in applicable fields to apply; and
 - Does not include emerging and disruptive technology visa holders in any other visa category cap.

Recommendation: Broaden the Scope of “Extraordinary” Talent to Make the O-1 Visa More Accessible and Emphasize AI Talent.

The O-1 temporary worker visa is for people with extraordinary ability or achievement.²⁷ O-1 visas are valid for three years and can be renewed annually an unlimited number of times. There is also no limit on the number of visas issued per year. Currently, about 15,000 to 18,000 new O-1 visas are issued annually.²⁸ For these reasons, the O-1 visa is generally a more flexible visa category than the H-1B visa, which is, with some exceptions, capped in duration and number.²⁹

While O-1 visas provide many advantages, they are a poor fit for many highly skilled workers due to the uncertainty of their criteria and the administrative burden of the application and adjudication process. Adjudicators determine an applicant’s eligibility through subjective assessments of whether applicants received nationally recognized prizes, have been published in major outlets, done original work of major significance, and other similar criteria. For the sciences and technology, this aligns largely with academic criteria such as publications in major outlets, and is not well suited for people who excel in industry.

²⁶ Oren Etzioni, *What Trump’s Executive Order on AI Is Missing: America Needs a Special Visa Program Aimed at Attracting More AI Experts and Specialists*, Wired (Feb. 13, 2019), <https://www.wired.com/story/what-trumps-executive-order-on-ai-is-missing/>.

²⁷ O-1A is the relevant O-1 category for STEM; it also encompasses those in “education, business, or athletics”. *O-1 Visa: Individuals with Extraordinary Ability or Achievement*, U.S. Citizenship & Immigration Services (last accessed Jan. 29, 2021), <https://www.uscis.gov/working-in-the-united-states/temporary-workers/o-1-visa-individuals-with-extraordinary-ability-or-achievement/>.

²⁸ *Nonimmigrant Visas Issued by Classification*, U.S. Department of State (last accessed Jan. 29, 2021), <https://travel.state.gov/content/dam/visas/Statistics/AnnualReports/FY2020AnnualReport/FY20AnnualReport-TableXVB.pdf>.

²⁹ *H1-B Fiscal Year (FY) 2021 Cap Season*, U.S. Citizenship & Immigration Services (last accessed Jan. 29, 2021), <https://www.uscis.gov/working-in-the-united-states/temporary-workers/h-1b-specialty-occupations-and-fashion-models/h-1b-fiscal-year-fy-2021-cap-season>.

Actions for the U.S. Citizenship and Immigration Service (USCIS):

- **Issue new guidance with clear and broad standards for regulatory criteria, such as what counts as a major outlet, nationally recognized prize, or original work.**
 - For example, if a publication in a top 5 academic journal within a scientists' field counts as a major outlet, many PhD graduates would likely qualify.
- **Initiate a regulatory process to decrease the threshold for eligibility for an O-1 visa, for example by reducing the number of criteria an applicant has to fulfill.**
 - The current standard is 3 out of 8 criteria.³⁰
- **Broaden criteria to better accept non-academic AI and STEM accomplishments.**
 - For instance, some top-tier engineers have not earned an undergraduate degree or published major papers, and instead focused on developing and monetizing cutting-edge technology in the private sector. New criteria should make O-1 visas more accessible to this demographic.

Recommendation: Implement and Advertise the International Entrepreneur Rule

The International Entrepreneur Rule (IER) allows USCIS to grant a period of authorized stay to international entrepreneurs who demonstrate that “their stay in the United States would provide a significant public benefit through their business venture.”³¹ The IER would be relatively easy for the Executive Branch to implement and is more directly tied to job creation than most other immigration proposals, making it more helpful to most Americans.

Action for the President:

- **An immediate executive action could announce the administration’s intention to use the IER to boost immigrant entrepreneurship, job creation for Americans, and economic growth.**

Actions for the USCIS:

- **Announce that it will give priority to entrepreneurs active in high-priority STEM fields such as AI, or in fields that use AI for other applications, such as agriculture.**
- **Use capital capture as a screening criterion for entrepreneurs.**
- **Emphasize job creation for Americans—potentially emphasizing underserved regions or areas with high unemployment—as a core factor in its assessment of significant public benefit.**

³⁰ 8 C.F.R. 214.2(o)(3)(iii)(b).

³¹ *International Entrepreneur Parole*, U.S. Citizenship & Immigration Services (last accessed Jan. 29, 2021), <https://www.uscis.gov/humanitarian/humanitarian-parole/international-entrepreneur-parole>. There is currently no visa category well-suited to entrepreneurship in U.S. statutes related to immigration. The IER, which relies on parole authority, was initiated after legislative avenues were exhausted. Legislative fixes would be preferable, but have so far proven politically infeasible.

Recommendation: Expand and Clarify Job Portability for Highly Skilled Workers

The Department of Homeland Security (DHS) published a final rule in November 2016 that made a number of reforms to improve temporary work visa programs, including some measure of relief for workers tethered to the employer sponsoring their green card petition during a potentially decades-long waiting period.³² The rule allows workers on H-1B, O-1, and other temporary work visas to obtain open market work permits for a one-year renewable period under compelling circumstances. Compelling circumstances include:

- Serious illness or disability faced by the worker or his/her dependents,
- Employer retaliation against the worker,
- Other substantial harm to the worker, and
- Significant disruption to the employer.³³

The criteria for compelling circumstances are too limited and ambiguous. Expanding visa holders' ability to obtain a work permit would allow for greater rates of entrepreneurship, tighter skill-matching with new employers, and allow visa holders to negotiate compensation on a level playing field with domestic workers.

Actions for the USCIS:

- **Clarify when highly skilled, nonimmigrant workers are permitted to change jobs or employers;**
- **Increase job flexibility when an employer either withdraws their petition for an H-1B or goes out of business, is acquired, or downsize; and**
- **Increase flexibility for H-1B workers seeking other H-1B employment.**

Recommendation: Recapture Green Cards Lost to Bureaucratic Error

Congress mandates annual caps on the number of green cards that may be issued to certain family-based immigrants (226,000) and employment-based immigrants (140,000).³⁴ Because federal agencies do not want to exceed the annual green card caps, they generally issue fewer green cards than they are allowed to. Due to this trend, as of 2009, the Federal government had not issued over 326,000 green cards.³⁵ The number today is likely higher, but DHS has not published updated statistics.

³² 81 Fed. Reg. 82398, *Retention of EB-1, EB-2, and EB-3 Immigrant Workers and Program Improvements Affecting High-Skilled Nonimmigrant Workers*, U.S. Department of Homeland Security (Nov. 18, 2016), <https://www.federalregister.gov/d/2016-27540>.

³³ Id.

³⁴ Julia Gelatt, *Explainer: How the U.S. Legal Immigration System Works*, Migration Policy Institute (Apr. 2019), <https://www.migrationpolicy.org/content/explainer-how-us-legal-immigration-system-works>.

³⁵ A 2009 report to Congress indicates that some 242,000 unused family-based green cards were ultimately applied to the employment-based backlog. Congress also recaptured some 180,000 out of roughly 506,000 unused employment preference green cards via special legislation, leaving over 326,000 green card numbers wasted out of the nearly 750,000 unused green cards. *Annual Report 2010*, Department of Homeland Security Citizenship and Immigration Services Ombudsman at 35 (June 30, 2010), https://www.dhs.gov/xlibrary/assets/cisomb_2010_annual_report_to_congress.pdf.

Actions for the Departments of Homeland Security and State

- **Publish an annual report on the number of green cards lost due to bureaucratic error.**
- **Review whether existing authorities can be used to:**
 - **Issue lost green cards the subsequent year without counting against green card caps.**
 - **Prioritize highly skilled immigrants who have waited the longest, followed by highly skilled immigrants with long projected wait times.**
- **If existing authorities are insufficient, engage with Congress to recapture green cards lost to bureaucratic error through special legislation.**

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Chapter 11: Accelerating AI Innovation

Blueprint for Action

The United States remains the world's artificial intelligence (AI) leader. However, trends within the United States indicate underlying weaknesses. The federal government holds the responsibility to provide strategic direction and long-term resources to strengthen the nation's foundation for AI innovation. The United States—through government leadership, and in partnership with industry and academia—must increase the diversity, competitiveness, and accessibility of its AI innovation environment to ensure continued leadership.

Recommendation: Scale and Coordinate Federal AI R&D Funding

The United States must reinforce the foundation of technical leadership in AI by enacting a bold, sustained federal push to invest in AI research and development to foster a nationwide landscape of AI innovation and drive breakthroughs in the next generation of AI technologies by establishing a National Technology Foundation, funding AI R&D at compounding levels, establishing additional National AI Research Institutes, and making big bets on talent and innovative ideas.

Component 1: Establish a National Technology Foundation

In the wake of Russia's successful launch of the Sputnik satellite in 1957, Congress made significant investments in the National Science Foundation (NSF) to shore up U.S. leadership in science and technology.³⁶ Since then, the NSF has supported research across the frontiers of science and engineering, funding efforts that contributed to the development of the Internet, smartphones, and additive manufacturing.³⁷ However, in today's heightened geopolitical technology competition, even bolder action is needed to meet the promise of emerging and disruptive technologies like AI, drive US innovation towards the national interest, and secure our economic future.

The Commission recommends the creation of a National Technology Foundation (NTF) as an independent federal agency and sister organization to the NSF to provide the means to move science more aggressively into engineering, and scale innovative ideas into reality. This will require an organization that is structured to accept higher levels of risk and empowered to make big bets on innovative ideas and people. It also demands an emphasis on the transition of technology from the lab to the market.

³⁶ *The National Science Foundation: A Brief History*, National Science Foundation (July 15, 1994), <https://www.nsf.gov/about/history/nsf50/nsf8816.jsp#chapter3> (“In fiscal year 1958, the year before Sputnik, the Foundation's appropriation had leveled at \$40 million. In fiscal 1959, it more than tripled at \$134 million, and by 1968 the Foundation budget stood at nearly \$500 million.”).

³⁷ *12 Irreplaceable Innovations Made Possible by NSF*, National Science Foundation (last accessed Feb. 11, 2021), https://www.nsf.gov/news/special_reports/btyb/innovation.jsp. A recent report produced by Computer Science and Telecommunications Board of the National Academies of Sciences, Engineering, and Medicine traces the interplay between fundamental research in information technology (IT) in academia and industry and its effects on capabilities of IT and non-IT sectors. For an illustration of the how the research funded by NSF and others has influenced the technologies that have transformed our everyday lives, see *Information Technology Innovation: Resurgence, Confluence, and Continuing Impact*, National Academies of Sciences, Engineering, and Medicine at 14 (2020), <https://doi.org/10.17226/25961>.

The current federal R&D posture lacks an organization that provides the level of investment and focus in applied research and technology engineering commensurate with the benefit technology breakthroughs could bring to the U.S. economy, society, and national security. In contrast to fundamental science, technology development embodies a more costly undertaking,³⁸ requires the support of a diverse base of researchers and developers—including private sector partners, and involves regular risk-taking. DARPA does this effectively, but for specific national security-focused ends and primarily through a prescribed program-based approach.

The NTF would drive technology progress at a national level by focusing on generating value at intermediate levels of technical maturity, prioritizing use-inspired concepts, establishing infrastructure for experimentation and testing, and supporting commercialization of successful outcomes. It would work in close concert with the NSF, DARPA, and other interagency partners to strengthen investment in domestic Science and Technology (S&T), providing the fuel for the development and delivery of AI and other technologies on which future economic progress and national security advantages rely.

To provide the level of attention to advance technologies of strategic importance, the NTF should focus efforts around a set of routinely updated priority research areas, such as those the Commission has identified as technologies critical to U.S. national competitiveness:³⁹

1. Artificial Intelligence
2. Biotechnology
3. Quantum Computing
4. Semiconductors and Advanced Hardware
5. Robotics and Autonomy
6. 5G and Advanced Networking
7. Advanced Manufacturing
8. Energy Technology

We do not underestimate the challenge of establishing a new institution. However, we see it as a strategic imperative. The NTF represents a long-term investment in America's ability to lead in AI and other disruptive technologies and apply technology towards efforts of societal importance. It would provide access to the resources and tools that could promote a national culture of experimentation and invention with new technology.

Given the criticality of holistically strengthening the national R&D landscape, the NTF should not detract from the level of appropriations for NSF, DARPA, or other existing federal R&D efforts. Rather, it should be instantiated as part of a broader approach that bolsters NSF as an

³⁸ We recommend an estimated operating budget of \$20 billion per year. For comparison, NSF has an annual budget of \$8.5 billion (FY 2021), while five U.S. technology firms—Alphabet, IBM, Facebook, Microsoft, and Amazon—spent an estimated \$80.5 billion on AI R&D alone in 2018. See *About the National Science Foundation*, National Science Foundation (last accessed Feb. 11, 2021), <https://www.nsf.gov/about/>; Martijn Rasser, et al, *The American AI Century: A Blueprint for Action*, CNAS (Dec. 17, 2019), <https://www.cnas.org/publications/reports/the-american-ai-century-a-blueprint-for-action>;

³⁹ See Chapter 16 of this report for additional details on each of these technologies, and why the Commission believes they are critical to future U.S. national competitiveness.

institution of enduring, critical importance, and amplifies federal support for technology R&D through existing channels as the organization gets off the ground.

Action for Congress:

- **Authorize and appropriate funding to support the establishment of the NTF.**
 - To match the envisioned enlargement of U.S. technology efforts, federal investment in the NTF should gradually increase from Fiscal Year 2022 to Fiscal Year 2026 for an ultimate estimated operating budget of \$20 billion per year.
 - Additional funds for facilities and equipment necessary for the Foundation’s creation, estimated at around \$30 million, should be made available starting in Fiscal Year 2022.
 - A National Technology Board—with members appointed by the President—should be created to provide policy direction to the NTF, supervise the Foundation’s major initiatives, and ensure that its research focus areas are updated to reflect technology trends. The Board’s directives and actions should be informed by the National Technology Strategy proposed by the Commission, and when necessary, coordinated with the Technology Competitiveness Council—both of which are separately recommended in this report.⁴⁰
 - Jointly, a Director and Deputy Director appointed by the President should coordinate programming across the Foundation’s directorates and with external organizations.
 - The NTF should be empowered to implement a portfolio of responsibilities:
 - Distribute funding through grants, cooperative agreements, and contracts awarded through competitive, risk-acceptant processes to academic and private sector researchers, nonprofits, and consortia.
 - Manage a component of its funding through an innovation unit modeled on DARPA where independent program managers would fund proposals from both industry and academia to advance solutions to forward-looking research questions.
 - Promote the transfer of technology advancements to the government as well as the commercial sector.
 - Run prize competitions to catalyze research around significant technology challenge problems.
 - Manage national technology resources and infrastructure that democratize an ability to build, test, and experiment.
 - Contribute to the success of the regional innovation clusters envisioned by the Commission by participating in the proposed technology program office and liaising with industry at Technology Research Centers.
 - Contribute to international R&D collaborations and standards-setting dialogues that strengthen U.S. strategic partnerships.

⁴⁰ For additional details on the Commission’s proposed National Technology Strategy and the Technology Competitiveness Council, see Chapter 9 of this report.

Component 2: Increase Federal Funding for Non-Defense AI R&D at Compounding Levels and Prioritize Key Areas of AI R&D

Research is the lynchpin of America’s global leadership in AI. However, current federal funding is not adequate to meet the growth of the field, let alone support its continued expansion.⁴¹ The Trump Administration’s proposed budget for non-defense AI research and development (R&D) in Fiscal Year 2021 was \$1.5 billion,⁴² a growth from the just under \$1 billion spent in Fiscal Year 2020.⁴³ Further building on this investment, Congress included the National AI Initiative Act of 2020 in the National Defense Authorization Act for Fiscal Year 2021 which creates a structure for a more strategic approach to harnessing AI and includes additional investments in AI at the NSF, Department of Energy (DoE), National Institute of Standards and Technology (NIST), and the National Oceanic and Atmospheric Administration.⁴⁴

National AI Initiative Act of 2020

- Created an executive branch entity within the Office of Science and Technology Policy to coordinate federal support for AI research and development, education and training, research infrastructure, and international engagement in order to achieve national priorities as defined in a regularly-updated strategic plan for AI.⁴⁵
- Included provisions that established a National AI Research Resource task force, formalized the National AI Research Institute effort, and authorized funding for AI research at the National Science Foundation, the National Institute of Science and Technology, the Department of Energy, and the National Oceanic and Atmospheric Administration.

The government should build on these first moves and invest in AI R&D at compounding levels. Federal research funding holds the power to change the trends that are degrading the ability of the U.S. to continue to lead in AI, namely that academic research is weakening as a result of brain drain of professors and diversion of graduate students to industry, the domestic AI talent pipeline is not keeping up with government and industry needs, and national technical and

⁴¹ For example, NSF, which provides 85% of federal funding for computer science, funded \$188 million in core AI research in 2019, but did not have room in the budget to fund another \$178 million worth of highly-rated proposals. This was an improvement from 2018, when they funded \$165 million, but left \$185 million of highly-rated work unfunded. Furthermore, NSF (in partnership with the Department of Agriculture) funded seven National AI Research Institutes in 2020, but were unable to fund the more than 30 that were judged worthy of supporting. NSF presentation to NSCAI (January 2020).

⁴² *The Networking & Information Technology Research & Development Program Supplement To The President’s FY2021 Budget*, National Science & Technology Council at 4 (Aug. 14, 2020), <https://www.nitrd.gov/pubs/FY2021-NITRD-Supplement.pdf>.

⁴³ *The Networking & Information Technology Research & Development Program Supplement To The President’s FY2020 Budget*, National Science & Technology Council at 11 (Sept. 2019), <https://www.nitrd.gov/pubs/FY2020-NITRD-Supplement.pdf>.

⁴⁴ Pub. L. 116-283, William M. (Mac) Thornberry National Defense Authorization Act for Fiscal Year 2021, 134 Stat. 3388 (2021).

⁴⁵ The legislation tasks an interagency committee overseen by the National AI Initiative Office to develop every three years a strategic plan for AI that: determines and prioritizes areas of AI R&D requiring Federal Government leadership and investment; supports long-term funding for interdisciplinary AI research; provides or facilitates the availability of curated, standardized, secure, representative, aggregate, and privacy-protected data sets for AI R&D; provides or facilitates the necessary computing, networking, and data facilities for AI R&D; supports and coordinates Federal education and workforce training activities; and supports and coordinates the network of artificial intelligence research institutes

ethical standards for development are lagging behind the technology.⁴⁶ Furthermore, federal support can spur the application of AI to other fields of science and engineering, which holds the potential for significant returns on investment.

Through sustained investments, federal support can serve to holistically strengthen AI R&D by embracing a range of initiatives—to include support for basic and applied research, shared research infrastructure, a network of AI R&D institutes, fellowships, and challenge competitions. Flowing investments through a diversity of agencies will create a vibrant fabric of funding, both mission-oriented and investigator-driven, that balances sustainment of evolutionary progress with big bets on revolutionary breakthroughs and supports innovation in academia and the private sector.

Actions for Congress:

- **Double annual non-defense AI R&D funding to reach \$32 billion by Fiscal Year 2026.**
 - Congress should support compounding levels of federal funding for AI R&D, doubling investments annually from the baseline of \$1 billion in Fiscal Year 2020.
 - Investments should be made across federal R&D funding agencies, notably the proposed National Technology Foundation, the Department of Energy (DoE), the National Science Foundation (NSF), the National Institutes of Health (NIH), the National Institute of Standards and Technology (NIST) and the National Aeronautics and Space Administration (NASA).
 - Significant funds should be appropriated to expand fellowship and scholarship programs.⁴⁷ Augmented funding through these vehicles would support additional undergraduate and graduate students to pursue AI-related fields of study, helping to strengthen academia, grow the domestic talent pipeline, and provide pathways into government for technical talent. Similarly, career/faculty fellowship vehicles supporting researchers in academia would serve to stem the flow of researchers to industry and invest in top talent to pursue big ideas.
- **Commit to spending at least 1 percent of GDP on federally-funded R&D.**
 - To maintain a strong base of innovation across S&T, Congress should pair AI-specific investments with an overall federal commitment to annually fund R&D at

⁴⁶ See *Interim Report*, NSCAI at 24-28 (Nov. 2019), <https://www.nscai.gov/previous-reports/>; Craig Willis, *Analysis of Current and Future Computer Science Needs via Advertised Faculty Searches for 2019*, CRA Bulletin (Dec. 7, 2018), <https://cra.org/analysis-of-current-and-future-computer-science-needs-via-advertised-faculty-searches-for-2019/>.

⁴⁷ Expanded funding could go through programs across federal agencies, notably the following. For NSF: CAREER fellowship; Graduate Research Fellowship Program; CyberCorps: Scholarship for Service; Historically Black Colleges and Universities Undergraduate Program; and Research Traineeship. For DOE: Early Career Research Program; Computational Science Graduate Fellowship. For NASA: Space Technology Research Fellowship program. For DoD: DARPA Young Faculty Award; Vannevar Bush Faculty Fellowship; Science, Mathematics, and Research for Transformation Scholarship for Service Program; National Defense Science and Engineering Graduate Fellowship Program; and Historically Black Colleges/Universities and Minority-Serving Institutions Research and Education Program. See Chapter 10's recommendation for the passage of a National Defense Education Act.

a level that reaches at least 1 percent of gross domestic product (GDP). This could be accomplished through steady growth over the next five years, at a rate of about \$15 billion per year.

Actions for the Office of Science and Technology Policy:

- **Balance Interagency AI R&D Investment Portfolios.**
 - The National AI Initiative should coordinate federal investments in AI R&D towards annual doubling benchmarks, through amplified research funding, fellowships, and establishment of research infrastructure.
 - The National AI Initiative should ensure growth in funding occurs across multiple agencies and embodies a portfolio approach that leverages a diverse set of mechanisms, focused on a range of outcomes—advancement of basic science, solving specific challenge problems, and facilitating commercialization of breakthroughs.

- **Prioritize Critical AI Research Areas.**
 - Research investments should prioritize areas critical to advance AI technology that will underpin future national security and economic growth, but may not receive significant private sector investment, such as:
 - *Novel machine learning directions.* To further non-traditional approaches to supervised machine learning in an unsupervised or semi-supervised manner as well as the transfer of learning from one task or domain to another.
 - *Testing, evaluation, verification, and validation (TEVV) of AI systems.* To develop a better understanding of how to conduct TEVV and build checks and balances into an AI system, including improved methods to explore, predict, and control individual AI system behavior so that when AI systems are composed into systems-of-systems their interaction does not lead to unexpected negative outcomes. Understand context-specificity and degradation of performance in new and unseen environments.
 - *Robust and resilient machine learning.* To cultivate more robust methods that can overcome adverse conditions, and advance approaches that enable assessment of types and levels of vulnerability and immunity. Addressing challenges of multiple classes of adversarial machine learning attacks. Includes research on fairness.
 - *Complex multi-agent scenarios.* To advance the understanding of interacting cohorts of AI systems, including research into adversarial vulnerabilities and mitigations, along with the application of game theory to varied and complex scenarios.

- *AI for modeling, simulation, and design.* To progress the use of rich simulations as a source of synthetic data and scenarios for training and testing AI systems, and to use AI to solve complex analytical problems and serve as a generative design engine in scientific discovery and engineering.
- *Advanced scene understanding.* To evolve perceptual models to incorporate multi-source and multi-modal information to support enhanced actionable awareness and insight across a range of complex, dynamic environments, and scenarios.
- *Preserving personal privacy.* To assure personal privacy of individuals is protected in the acquisition and use of data for AI system development and operation through advancements in anonymity techniques and privacy-preserving technologies such as homomorphic encryption, differential privacy techniques, and multi-party federated learning.
- *AI system risk assessment.* Advance capabilities to support risk assessment including standard methods and metrics for evaluating degrees of auditability, traceability, interpretability, explainability, and reliability.
- *Enhanced human-AI interaction and teaming.* To advance the understanding of human-AI teaming, including human-AI complementarity, methods for augmenting human reasoning abilities, fluid handoffs in mixed-initiative systems. Also includes bolstering AI technologies to better perceive and understand human intention and communications, including comprehension of spoken speech, written text, and gestures. Advances in human-machine teaming will enable human interactions with AI-enabled systems to move from the current model of interaction where the human is the “operator” to a future in which humans have a “teammate” relationship with machines.
- *Autonomous AI systems.* To advance a system’s ability to accomplish goals independently, or with minimal supervision from human operators in environments that are complex and unpredictable.
- *Toward more general artificial intelligence.* Research persistent challenging problems, and mysteries of human intellect, including ability to learn efficiently in an unsupervised manner; amass and apply commonsense knowledge; build causal models that provide robust explanations; exercise self-awareness, assessment, and control; and generalize and leverage knowledge learned about specific tasks to become proficient at another task.

Component 3: Triple the Number of National AI Research Institutes

NSF awarded grants for the first national AI research institutes in 2020, supporting seven university-based, multi-institution consortia organized around fundamental and applied areas of AI research—topics for which were determined through coordination with interagency and community stakeholders.⁴⁸ NSF plans to fund a second round of institutes in 2021, coordinating support not only with interagency partners but also with private sector stakeholders to launch eight additional institutes.⁴⁹ Congress took steps to support the initiative through the National AI Initiative Act of 2020, which formalizes the effort, provides all agencies the authority to financially support formation of a National AI Research Institute, and directs NSF to bring together the institutes as an “Artificial Intelligence Leadership Network.”⁵⁰

Expansion of this initiative would create a nationwide network of AI innovation that supports a breadth of AI research initiatives—advancing basic AI science, solving domain-specific challenges, and applying AI to other fields of science and engineering. Their establishment would increase training opportunities for students and research opportunities for academic faculty, national lab researchers, and non-profit research organizations; help grow the field outside of leading private universities and regional technology hub; and strategically steer research towards areas that could advance the science of AI and applications that serve broader society and the national interest.

Action for Congress:

- **Direct and appropriate funds to expand the network of AI institutes.**
 - Congress should direct and appropriate funds to NSF to expand the network of AI institutes three-fold over the course of the next three years—ideally resulting in a broad diversity of participating institutions, regions, and research concentrations.
 - This investment would encompass 30 additional institutes, totaling \$600 million to sustain the additional institutes for the five-year duration of the grant awards. This would entail appropriations of \$200 million in Fiscal Year 2022, Fiscal Year 2023, and Fiscal Year 2024.

Action for the Office of Science and Technology Policy:

- **Integrate the network of institutes with national AI R&D infrastructure investments.**

⁴⁸ The topics were: Trustworthy AI; Foundations of Machine Learning; AI-Driven Innovation in Agriculture and the Food System; AI-Augmented Learning; AI for Accelerating Molecular Synthesis and Manufacturing; and AI for Discovery in Physics. The Department of Agriculture teamed with NSF to provide funding toward two of the institutes, to support AI research on developing the next-generation of and resilience in agriculture. *Artificial Intelligence at NSF*, NSF (Aug. 26, 2020), <https://www.nsf.gov/cise/ai.jsp>.

⁴⁹ Around the topics of: Human-AI Interaction and Collaboration, Advances in Optimization, AI and Advanced Cyberinfrastructure, Advances in AI and Computer and Network Systems, Dynamic Systems, AI-Augmented Learning, AI to Advance Biology, and AI-Driven Innovation in Agriculture and the Food System. The institutes are funded at a rate of \$4 million per year for five years, totaling \$20 million. *Artificial Intelligence at NSF*, NSF (Aug. 26, 2020), <https://www.nsf.gov/cise/ai.jsp>.

⁵⁰ Pub. L. 116-283, sec. 5201(b), William M. (Mac) Thornberry National Defense Authorization Act for Fiscal Year 2021, 134 Stat. 3388 (2021).

- The National AI Initiative should ensure alignment of the National AI Research Institutes with strategic research priorities and integration with the national network of open AI test beds and the National AI Research Resource (see discussion of a National AI Research Infrastructure below).

Component 4: Invest in Talent that Will Transform the Field

Top talent in AI is a scarce commodity, and investing in talent holds the potential to not only unlock breakthroughs in the science and application of AI but also to attract and retain top talent in the United States.⁵¹ Similarly, investing in research initiatives conducted by integrated, multi-disciplinary teams is a proven mechanism to prompt breakthroughs, address complex problems, and challenge the status quo.⁵²

The launch of an AI Innovator Award and complementary team-based AI award would strengthen the ability of federal AI research funding to push the boundaries of the field, providing a mechanism to complement ongoing investments in incremental progress with bets on revolutionary breakthroughs.

Actions for Congress:

- **Direct and fund establishment of an AI Innovator Award.**
 - Congress should direct and fund NSF to establish an AI Innovator Award, loosely modeled on that of the National Institutes of Health (NIH) Pioneer Award⁵³ and the Howard Hughes Medical Institute Investigator Program⁵⁴ to create a

⁵¹ A 2019 evaluation of the grants made as a component of the National Institutes of Health (NIH) high-risk, high-reward program—which include large, longer term investments in talent through the NIH Director’s Pioneer Award, NIH Director’s New Innovator Award, and the NIH Director’s Early Independence Award—found that these awards funded highly productive research compared to the work funded under traditional NIH research grants and that they result in a higher technological impact. The high-risk, high-reward program was created to accelerate the pace of biomedical, behavioral, and social science discoveries by supporting creative scientists with highly innovative research. See *Report of the ACD Working Group on High-Risk, High-Reward Research*, National Institutes of Health Advisory Committee to the Director (June 2019), https://www.acd.od.nih.gov/documents/presentations/06132019HRHR_B.pdf.

⁵² Studies have found that research that effectively combines diversity of knowledge is more likely to prompt breakthroughs and that interdisciplinary research lends itself to complex problem solving, developing new research thrusts, and challenging the status quo. See Lee Fleming, *Recombinant Uncertainty in Technological Search*, Management Science (Jan. 2001), <https://funginstitute.berkeley.edu/wp-content/uploads/2012/10/Recombinant-Uncertainty-in-Technological-Search.pdf>; Andrew Barry, et al., *Logics of Interdisciplinarity*, Economy and Society (Feb. 2008), <http://users.sussex.ac.uk/~ir28/IDR/Barry2008.pdf>.

⁵³ The NIH Director’s Pioneer Award supports researchers at any career stage who propose bold research projects with unusually broad scientific impact. The program supports awardees with \$3.5 million over 5 years, and requires 51% of time spent on research in the first three years. See *NIH Director’s Pioneer Award*, National Institutes of Health (last accessed Jan. 1, 2021), <https://commonfund.nih.gov/pioneer>. Competition for participation in the program is high, reportedly success rate for applicants is just 1 percent. See Roberta B. Ness, *The Creativity Crisis*, Oxford University Press at 87 (2015).

⁵⁴ Established in 1978, the Howard Hughes Medical Institute (HHMI) supports over 250 investigators across the United States. 30 current or former HHMI investigators have been awarded the Nobel Prize. The HHMI Investigator Program is organized around the core belief in the power of individuals to make breakthroughs over time. Through the program, which selects 20 investigators per year, HHMI aims to expand a community of basic researchers and physician scientists who catalyze discovery research in basic and biomedical sciences, plant biology, evolutionary biology, biophysics, chemical biology, biomedical engineering, and computational biology. See *Investigator Program*, HHMI (last accessed Feb. 3, 2021), <https://www.hhmi.org/programs/biomedical-research/investigator-program>; see also *Competition to Select New HHMI*

mechanism that provides top researchers the flexibility to pursue big ideas without prescribed outcomes over the course of a five-year, renewable grant award.

- Totaling around \$5.5 million per awardee for the five-year term, the awards would cover the full salary and benefits of the researchers at their respective institutions as well as a research budget that would support equipment and staff.⁵⁵
- At its height, the program would support a maximum of 100 researchers at a time, reaching an annual funding level of around \$125 million for research support, with additional funds available for major equipment support.
- Eligible researchers would be those at any career stage based at U.S. universities or research institutions, who commit to spending 75 percent of their time on research.⁵⁶
- Attention should be paid by the selection committee to the need for diversity among awardees—in terms of gender, race, age, location, and primary focus area of study; as well as on the communication and leadership skills of applicants.
- Congress should authorize NSF to:
 - Fund an external organization to administer the program.⁵⁷
 - Annually select between 10 to 20 recipients for five-year, renewable terms, and conduct selection through a small, rotating panel of AI experts.⁵⁸
 - Ensure selection of innovative candidates through an advocacy model process where candidates are ranked in accordance with the maximum scores provided by reviewers, thereby placing priority on their upside potential.⁵⁹
 - Hold an annual meeting in which all awardees would share their work, providing a venue for meaningful feedback between review cycles and helping build a community of innovation among the top U.S.-based minds in AI.

Investigators, HHMI (2020), <https://www.hhmi.org/sites/default/files/programs/investigator/investigator2021-program-announcement-200714.pdf>.

⁵⁵ This mirrors the HHMI structure and cost model, with HHMI awarding \$8 million over a seven-year term. HHMI updated the length of their award in 2018, extending the term length from five to seven years. See *HHMI Bets Big on 19 New Investigators*, HHMI (May 23 2018), <https://www.hhmi.org/news/hhmi-bets-big-on-19-new-investigators>.

⁵⁶ Should researchers move institutions over the course of the program, the award would move with them.

⁵⁷ This could be conducted through a cooperative agreement, mirroring the relationship NSF formed with the Computing Research Association to launch the Computing Innovation Fellows program in 2009 to support post-doctoral PhDs imperiled in finding academic appointments by the downturn of the economy. See *CIFellows*, Computing Community Consortium (last accessed Jan. 1, 2021), <https://cra.org/ccc/leadership-development/cifellows/>. Furthermore, this entity would be able to accept supplemental funding from individuals, corporations, or other non-profits to further strengthen and expand the program.

⁵⁸ They would provide meaningful feedback to selectees throughout their participation in the program. The quality of feedback provided by reviewers was identified by researchers as a key factor in the success of HHMI investigators. Pierre Azoulay, et al., *Incentives and Creativity: Evidence from the Academic Life Sciences*, NBER (Dec. 2011), <https://www.nber.org/papers/w15466>.

⁵⁹ Pierre Azoulay & Danielle Li, *Scientific Grant Funding*, MIT & NBER (Mar. 4, 2020), <https://mitsloan.mit.edu/shared/ods/documents/?PublicationDocumentID=6296>. See also the “gold award” model used by the Gates Foundation. *How Grand Challenges Explorations Grants are Granted*, Bill & Melinda Gates Foundation Global Grand Challenges (last accessed Feb. 3, 2021), <https://gcgh.grandchallenges.org/how-grand-challenges-explorations-grants-are-selected>.

- Congress should require NSF to assess the program after seven years of operation to determine whether the program should continue to expand or operate at a lower number of awards, and to evaluate the impact of the funding level and award term on the research conducted by participants.
- **Direct and fund establishment of a team-based AI research award.**
 - Congress should direct and fund NSF to work with the same external organization as the AI Innovator Award to create a team-based award to support bold, interdisciplinary research initiatives that apply AI to solve complex challenge problems or pursue use-inspired basic research efforts.⁶⁰
 - The program should begin with an annual budget of \$50 million, growing to a sustained annual budget of \$250 million by its fifth year of operation.
 - Congress should authorize the NSF to:
 - Fund an external organization to administer the program.
 - Select 5-10 teams annually for non-renewable, five-year terms, awarding \$4-\$10 million per year for the five-year term of the award.⁶¹

Recommendation: Expand Access to AI Resources through a National AI Research Infrastructure

If not addressed, the growing divide between “haves” and “have nots” in AI R&D will degrade the long-term research and training functions performed by U.S. universities, limit the ability of small businesses to innovate, and exacerbate the lack of diversity in the field.⁶² While developments in the past five years have dramatically increased access to baseline machine learning (ML) tools and cloud-based computation, progress on the cutting edge of many important AI approaches requires significant amounts of data and computing power, expensive infrastructure, and substantial hardware and software engineering.

The United States should foster the world’s leading environment for AI innovation through democratized access to AI R&D that supports more equitable growth of the field and expansion of AI expertise across the country; enables application of AI to a broad range of fields of science and engineering, commercial sectors and public services; and fuels the next waves of innovation.

Component 1: Launch the National AI Research Resource

⁶⁰ As argued by Donald Stokes in 1997, research should be conceived not as a dichotomy between basic and applied research, but on a quadrant along the axes of "quest for fundamental understanding" and "considerations of use." Research in the upper right quadrant is defined as use-inspired basic research -- research that advances fundamental knowledge but is driven by a clear purpose. Stokes calls this “Pasteur’s quadrant” after the work of Louis Pasteur, whose research pushed scientific boundaries and had practical applications. See Cherie Winner, *Pasteur’s Quadrant*, Washington State Magazine (2009), <https://magazine.wsu.edu/web-extra/pasteurs-quadrant/>.

⁶¹ Amount of award would be adjusted in accordance with the specificities of the project. Eligible teams would be composed of researchers based in U.S. academic or research institutions proposing innovative work related to AI.

⁶² The annual Taulbee study that tracks the field of computer science (CS) found that women make up 21.0 percent of CS bachelors graduates and 20.3 percent of CS doctoral graduates, and domestic underrepresented minorities 14.7 percent of CS bachelor degrees awarded and only 3.1 percent of doctoral graduates. Stuart Zweben & Betsy Bizot, *2019 Taulbee Survey*, Computing Research Association at 4-5, 22, (May 2020), <https://cra.org/wp-content/uploads/2020/05/2019-Taulbee-Survey.pdf>

Since the explosion of deep learning in 2012 and accompanying growth in use of specialized hardware for AI computing, there has arisen what some have termed the “compute divide”—a disparity in access between large technology companies and elite universities and mid- and lower-tier universities to the resources necessary for cutting-edge AI research.⁶³ Availability and type of compute resources have been found to levy “outsized” influence in the direction of research pursued by researchers, as has the ascendancy of the well-equipped firms in shifting the overall direction of AI research toward applied, “narrow AI” efforts.⁶⁴

To bridge the compute divide, the federal government should establish a National AI Research Resource (NAIRR) to provide verified researchers and students with access to compute resources, co-located with AI-ready government and non-government data sets, educational tools, and user support.⁶⁵ This infrastructure should leverage public-private partnerships and cutting-edge private sector technology, and build on existing government efforts⁶⁶—avoiding high start-up costs of a government-run data center. Congress has taken the first step in the Fiscal Year 2021 National Defense Authorization Act, implementing a component of the Commission’s prior recommendation to create a task force to develop a roadmap for a NAIRR.⁶⁷ The result of this effort will be due to Congress 18 months after appointment of task force members.

Action for Congress:

- **Authorize and appropriate \$30 million for implementation of the NAIRR roadmap.**
 - Congress should authorize and appropriate funds to immediately implement the roadmap developed by the NAIRR task force.
 - The resource should be sustained at an initial level of \$30 million annually, amplified by contributions from private sector partners, and scaled as it matures and gains users.
 - Funding would support staffing of the program and the cloud resources, augmented through public-private partnerships. Staff would be responsible for maintaining and improving the architecture solution, curating data sets, building interfaces and tools, and providing support to researchers.

Component 2: Create a Network of National AI Testbeds to Serve the Academic and Industry Research Communities

Sponsored through various federal agencies, this network of national AI testbeds would provide real-world, domain-specific resources open to the academic, business, and government research

⁶³ Nur Ahmed & Muntasir Wahed, *The De-democratization of AI: Deep Learning and the Compute Divide in Artificial Intelligence Research*, ArXiv (Oct. 22, 2020), <https://arxiv.org/abs/2010.15581>.

⁶⁴ Joel Klinger, et al., *A Narrowing of AI Research?*, ArXiv (Nov. 18, 2020), <https://arxiv.org/pdf/2009.10385.pdf>.

⁶⁵ This program may be realized as a single cloud resource or a federation of resources, the pros and cons of which should be considered by the Task Force with determinations made within their resulting roadmap.

⁶⁶ Such as the NSF’s Cloudbank, which brokers cloud access to specific NSF-funded researchers, and the COVID-19 High Performance Computing Consortium, a public-private partnership that grants access to a range of computing resources to serve COVID-19-related research. See Cloudbank (last accessed Jan. 2, 2021), <https://www.cloudbank.org/>; The COVID-19 High Performance Computing Consortium (last accessed Jan. 2, 2021), <https://covid19-hpc-consortium.org/>.

⁶⁷ Pub. L. 116-283, sec. 5106, William M. (Mac) Thornberry National Defense Authorization Act for Fiscal Year 2021, 134 Stat. 3388 (2021).

communities to drive basic and applied research to address complex problems, and develop robust, usable AI systems ripe for commercialization. For example, a self-driving vehicle test range, an instrumented humanitarian aid and disaster relief test site, or an instrumented home environment. Such resources would help establish and maintain benchmarking standards that enable measurable research progress through comparable approaches and reproducibility testing.

Testbeds should support experimentation with both novel software and hardware, equipped with rich simulation capabilities to model the physical world. Supported by simulated, live, and blended environments, these platforms would support research and experimentation that tackles open-ended, real-world problems. Furthermore, they should be architected to collect valuable data that could be made accessible to the community for training and evaluation, providing additional fuel for progress.

Action for the Office of Science and Technology Policy:

- **Coordinate agency investments in AI R&D testbed facilities.**
 - The National AI Initiative should coordinate agency investments in AI testbed facilities through the annual budget process, aligning investments with research priorities issued in the initiative’s strategic plan. Attention should focus on modernizing existing resources to support data-driven and AI-enabled technologies.⁶⁸

Action for Federal Agencies:

- **Invest in domain-specific AI R&D testbeds through upgraded or purpose-built facilities.**
 - Investment in the suite of national AI testbeds should be made across multiple federal agencies, facilitating creation of domain-specific resources open to the broader research community. Focus areas of each testbed should be aligned with priority AI research areas and in support of existing federal AI investments.
 - Testbeds should be set up as “user facilities” that maintain a hybrid approach of awarding grants for use and charging fees to those not selected for grant funding. User fees would assist in maintaining the testbeds and supplementing the amount of funding available for grants.

Action for Congress:

- **Support agency funding requests for establishment of AI R&D testbeds.**

Component 3: Invest in Large Scale, Open Training Data

⁶⁸ For example, AI testbeds could be hosted by DoE’s existing national laboratory facilities and high-performance computing resources or by DoD’s existing testing and evaluation infrastructure, or facilities managed by the Department of Transportation, NIH, National Institute of Standards and Technology (NIST), or the Department of Agriculture.

Data is critical currency for today’s popular AI approaches. Promising work in the realm of low-shot learning, semi-supervised learning, and learning from synthetic data provide glimpses of a future where performance of an AI system is not directly tied to big data, and the Federal Government should continue to prioritize funding for research in these areas. However, balancing these bets on the future with investments in resources to further U.S. leadership in the current leading AI approaches would strengthen the foundation of both current and future AI-based technology and applications.

Building AI systems and solutions for new domains and application areas relies on availability of specialized data that have been cleaned and organized for use. Federal support for well-designed, publicly-available data sets and provision of AI-ready government data sets would help drive research progress in AI and its application to other fields of study. Currently, a sizable amount of government data that is legal to share with trusted non-government researchers is not being shared due to a lack of confidence in cybersecurity and privacy protecting technologies, and a lack of willingness to accept risk.

Responsibly creating pipelines for the curation, hosting, and maintenance of complex data sets would set the foundation for future AI capabilities, help strategically steer the research community towards issues in the public interest, and advance technology around data set lifecycle maintenance.

These data investments could be further augmented by and created in support of the domain testbeds recommended above, and hosted through the NAIRR. This integration could foster creation of data sets to support benchmarks within the testbeds as well as generate rich data from testing that could be provided back out to serve the research community. Access to resources should be granted to researchers with verified research efforts, and governed by appropriate compliance controls based on the type of data and metadata contained in the data set.

Actions for the Executive Branch:

- **Issue a common policy and set of best practices.**
 - Leveraging the work of NIST,⁶⁹ the U.S. Chief Data Officer should issue a common policy and set of best practices to support release of AI-ready government data to the public, and work with industry and academia to adopt compatible policies and best practices for reciprocal sharing and documentation.
- **Provide incentives to industry and academia to make available select data sets.**
 - The U.S. Chief Data Officer should develop incentives for industry and academia to make available select data sets on the National AI Research Resource that would be managed and accessed alongside government-owned data sets.
- **Support NSF-funded cybersecurity and privacy researchers to make government**

⁶⁹ The National AI Initiative Act of 2020 tasks NIST to develop standards for AI data sharing and documentation. See Pub. L. 116-283, William M. (Mac) Thornberry National Defense Authorization Act for Fiscal Year 2021, 134 Stat. 3388 (2021).

data accessible for research purposes.

- The National AI Initiative should coordinate NSF-funded cybersecurity and privacy researchers to undertake rotational assignments at federal agencies⁷⁰ to work closely with agency personnel and data stewards to responsibly unlock access to more of the government’s data holdings for the purpose of stimulating AI research and innovation.
- Researchers would apply promising methodologies for protecting data and privacy in a controlled manner, providing a proving ground for new approaches and objective evidence to justify evolving data sharing policies and practices. This could include creating secure environments for verified researchers to access more sensitive government-held data.

Actions for Congress:

● **Unlock public data for AI R&D.**

- Congress should fund teams of data engineers and data scientists organized through the U.S. Digital Service to unlock public data currently held by the government for use by the AI research community.⁷¹
- These teams would prioritize, clean, and curate non-sensitive public data sets to make them AI-ready; and structure enduring processes to capture, clean, and regularly update data that would be hosted on a platform such as a NAIRR, accessible by verified U.S.-based researchers.

● **Fund an AI data program at the Department of Energy.**

- Congress should appropriate \$25 million⁷² per year for the next five years to DoE to administer an AI data program that would create exemplar, complex data sets and maintain them as living, regularly updated resources. These could include specialized data sets in physical, biological, earth and engineering sciences, as well as social sciences.⁷³

⁷⁰ Through such mechanisms as the Intergovernmental Personnel Act mobility program. *Intergovernmental Personnel Act*, U.S. Office of Personnel Management (last accessed Feb. 1, 2021), <https://www.opm.gov/policy-data-oversight/hiring-information/intergovernment-personnel-act/>.

⁷¹ Executive Order 13859 on AI called on federal agencies to “enhance access to high-quality federal data, models, and computing resources to increase their value for AI R&D.” See Donald J. Trump, *Executive Order on Maintaining American Leadership in Artificial Intelligence*, The White House (Feb. 11, 2019), <https://trumpwhitehouse.archives.gov/presidential-actions/executive-order-maintaining-american-leadership-artificial-intelligence/>.

⁷² This would provide for creation of five initial datasets, as well as maintenance over their lifetime and creation of additional data sets as the program matures.

⁷³ The DoE is well placed to manage such a program, leveraging the cross-disciplinary expertise resident throughout the laboratory network, the unique computing and user facilities housed at the 17 laboratories, and ability to create and maintain secure data environments. *User Facilities at a Glance*, U.S. Department of Energy: Office of Science (last accessed Jan. 2, 2021), <https://science.osti.gov/User-Facilities/User-Facilities-at-a-Glance#0>. The program could build on the pathfinder Open Data Initiative launched by Lawrence Livermore National Laboratory in partnership with the University of California San Diego, which hosts complex, labelled data sets for testing solutions for scalable machine learning platforms. See *New Partnerships Results in Increased Access to Compelling “Real World Data”*, UC San Diego (Apr. 21, 2020), <https://library.ucsd.edu/news-events/new-partnership-results-in-increased-access-to-compelling-real-world-data/>; *Open Data Initiative*, Lawrence Livermore National Laboratory (last accessed Jan. 2, 2021), <https://data-science.llnl.gov/open-data-initiative>.

- The program should be coordinated through the National AI Initiative to ensure data sets created steer the research community in desired directions.
- Congress should direct DoE to work closely with NIST to develop standards for the data—to include standards for documentation, data modeling, data engineering, and data formats as well as to advance the methods and tools necessary to support the data lifecycle.

Component 4: Sponsor an Open Knowledge Network

Open knowledge networks (or repositories) with massive amounts of world knowledge could fuel the next wave of AI exploration, driving innovations from scientific research to the commercial sector. Today, only the biggest tech companies have the resources to develop significant knowledge graphs and networks.

Various federal agencies have invested in specialized, domain-specific knowledge networks that could provide a starting point for an open knowledge network.⁷⁴ Beginning with a push to federate and map together existing specialized knowledge networks and government data platforms, and then building in real world knowledge and context, the government could sponsor an Open Knowledge Network that would serve verified U.S.-based companies and researchers of all backgrounds to use world knowledge to develop AI systems that operate effectively and efficiently. This type of resource, particularly if paired with the complementary research infrastructure above, could unlock frontiers of technology yet unexplored.

Action for the Office of Science and Technology Policy:

- **Hold an innovation sprint to build an open knowledge network roadmap.**
 - Leveraging prior work undertaken through the Networking and Information Technology Research and Development (NITRD) program Big Data Interagency Working Group,⁷⁵ the Office of Science and Technology Policy should hold an innovation sprint to build a roadmap to establish an open knowledge network in a phased manner.

Action for Congress:

- **Direct and fund implementation and management of the open knowledge network.**
 - Congress should direct and fund the NSF to implement and manage the open knowledge network, appropriating \$25 million per year for the next five years and

⁷⁴ For example NSF, NASA, NIH, and DARPA have all sponsored or created data resources relevant to an open knowledge network. In addition, government and community-led efforts to pool data to build solutions to the COVID-19 pandemic could be leveraged.

⁷⁵ *Open Knowledge Network: Summary of the Big Data IWG Workshop*, National Science & Technology Council (Nov. 2018), <https://www.nitrd.gov/pubs/Open-Knowledge-Network-Workshop-Report-2018.pdf>.

encouraging NSF to leverage partnerships with industry stakeholders where possible.⁷⁶

Recommendation: Leverage Both Sides of the Public-Private Partnership

U.S. companies are at the forefront of AI R&D, and their investments benefit consumers globally through the rapid development and adoption of AI-enabled products. But the impact of AI-enabled products on U.S. society and national security has largely come as an afterthought. The speed of technology development by the private sector has vastly outpaced federal policies and regulations. To address these challenges, the public and private sector must share responsibility for the safety, security, and well-being of Americans. The following recommendations would make the government a better partner for industry, broaden the benefits of strategic emerging technologies like AI through regional innovation clusters, and expand opportunities to access AI research and education through private sector philanthropy.

Component 1: Create Markets for AI and Other Strategic Technologies

The government's buying power cannot compete with a global consumer market, but it can influence investment decisions in technologies essential to overall U.S. technical leadership.⁷⁷ Many potential public-sector applications of AI—such as education and labor—fall under agencies with limited R&D budgets. As the government increases investment in basic research, it must also fully leverage its purchasing power to support AI and other strategic technologies.⁷⁸ The scale of government funding can influence the research priorities and viability of early-stage startups, which often succeed or fail in the first year; and if leveraged collectively, can draw private sector resources towards areas of strategic priority. This makes growing technology companies an important partner for AI R&D that can build future defense and national security capabilities.

Yet the government remains a difficult customer—especially for small and medium-sized businesses—because of its complex contracting process and unique requirements. Making the U.S. government a more compelling customer and effective buyer of commercial technology will drive technology development in the commercial sector that is in the national interest. It will also assist the government in almost every aspect of its mission—from providing basic public services, to driving economic policy and protecting national security.

⁷⁶ This would build on ongoing efforts through NSF's Convergence Accelerator track on Open Knowledge Networks. *NSF Convergence Accelerator Awards Bring Together Scientists, Businesses, Nonprofits to Benefit Workers*, NSF (Sept. 10, 2019), https://www.nsf.gov/news/special_reports/announcements/091019.jsp.

⁷⁷ For additional details and recommendations on technologies associated with AI that are important to U.S. technology leadership, see Chapter 13 of this report. A strategic industry is considered by the government to be very important to a country's economy or safety. In the national security context, it is considered critical to the country's competitive advantage over an adversary. While the US's 16 critical infrastructure sectors refer to large segments of the economy "whose assets, systems, and networks, whether physical or virtual, are considered so vital to the United States," a strategic industry refers to a much more specific group of companies or businesses. See *Critical Infrastructure Sectors*, Cybersecurity and Infrastructure Agency (last accessed Jan. 4, 2020), <https://www.cisa.gov/critical-infrastructure-sectors>; see also *Strategic Industry*, Cambridge Dictionary (last accessed Jan. 4, 2020), <https://dictionary.cambridge.org/dictionary/english/strategic-industry>.

⁷⁸ U.S. federal agencies collectively have an annual IT budget of \$90 billion—one tenth the annual revenue of the top 5 U.S. tech firms—yet the majority of government systems are "outdated and poorly protected." *An American Budget*, U.S. Office of Management and Budget at 9 (Feb. 2018), <https://trumpwhitehouse.archives.gov/wp-content/uploads/2018/02/budget-fy2019.pdf>.

Actions for the General Services Administration (GSA):

- **Promote the application of AI across the U.S. Government.**
 - In fulfilling its mandate to facilitate the adoption of artificial intelligence technologies in the Federal Government,⁷⁹ the AI Center of Excellence (AI CoE) should look first to readily available commercial off-the-shelf (COTS) technology that can be tailored for government use.
 - AI CoE should work with Federal technical leadership,⁸⁰ including the U.S. Chief Technology Officer, Chief Information Officer Council, and the National AI Initiative,⁸¹ to identify government needs and opportunities, and expedite the adoption of commercial AI applications across federal agencies.
 - The AI CoE should leverage existing digital governance efforts across the Executive Branch, including GSA’s 18F and the U.S. Digital Service, and technical talent exchange programs, including GSA’s Presidential Innovation Fellowship, to bring sufficient technical expertise and commercial proficiency to this effort.⁸²
- **Communicate federal AI capability priorities to the private sector**

⁷⁹ Congress, in the Consolidated Appropriations Act, 2021, called on the General Services Administration to create a 5-year program to be known as the “AI Center of Excellence” to “(1) facilitate the adoption of artificial intelligence technologies in the Federal Government; (2) improve cohesion and competency in the adoption and use of artificial intelligence within the Federal Government; and (3) carry out paragraphs (1) and (2) for the purposes of benefiting the public and enhancing the productivity and efficiency of Federal Government operations.” *Rules Committee Print 116-68, Text of the House Amendment to Senate Amendment to H.R. 133*, U.S. House Committee on Rules at 378 (Dec. 21, 2020), <https://rules.house.gov/sites/democrats.rules.house.gov/files/BILLS-116HR133SA-RCP-116-68.pdf> (referring specifically to section 103 of the Consolidated Appropriations Act, 2021).

⁸⁰ The Consolidated Appropriations Act, 2021, outlines AI CoE’s duties to include “advising the Director of the Office of Science and Technology Policy on developing policy related to research and national investment in artificial intelligence.” *Rules Committee Print 116-68, Text of the House Amendment to Senate Amendment to H.R. 133*, U.S. House Committee on Rules at 380 (Dec. 21, 2020), <https://rules.house.gov/sites/democrats.rules.house.gov/files/BILLS-116HR133SA-RCP-116-68.pdf>.

⁸¹ The National AI Initiative Act of 2020 directs the Director of OSTP to establish an “National Artificial Intelligence Initiative Office” within OSTP to “(1) provide technical and administrative support to the Interagency Committee and the Advisory Committee; (2) serve as the point of contact on Federal artificial intelligence activities carried out under the Initiative for Federal departments and agencies, industry, academia, nonprofit organizations, professional societies, State governments, and such other persons as the Initiative Office considers appropriate to exchange technical and programmatic information; (3) conduct regular public outreach to diverse stakeholders, including through the convening of conferences and educational events, the publication of information about significant Initiative activities on a publicly available website, and the dissemination of findings and recommendations of the Advisory Committee, as appropriate; and (4) promote access to and early adoption of the technologies, innovations, lessons learned, and expertise derived from Initiative activities to agency missions and systems across the Federal Government, and to industry, including startup companies.” Pub. L. 116-283, sec. 5102, William M. (Mac) Thornberry National Defense Authorization Act for Fiscal Year 2021, 134 Stat. 3388 (2021).

⁸² The Consolidated Appropriations Act, 2021, outlines AI CoE’s duties to include “advising the Administrator, the Director, and agencies on the acquisition and use of artificial intelligence through technical insight and expertise, as needed.” *Rules Committee Print 116-68, Text of the House Amendment to Senate Amendment to H.R. 133*, U.S. House Committee on Rules at 379 (Dec. 11, 2020), <https://rules.house.gov/sites/democrats.rules.house.gov/files/BILLS-116HR133SA-RCP-116-68.pdf>.

- The AI CoE should add federal procurement priorities and agency capability needs to its publicly available website, which contains information regarding programs, pilots, and other initiatives.⁸³

Actions for the U.S. Small Business Administration:

- **Publish a digital technology “playbook” for small businesses.**
 - A playbook for small businesses should outline paths for companies interested in doing business with the U.S. government and explain in a single place how to navigate challenges like obtaining access cards to government facilities. Such a resource would make the acquisitions process more transparent and reduce the need for companies to hire outside help.
 - The playbook should be developed and reviewed by personnel with technical and commercial proficiency, for example Presidential Innovation Fellows or staff from the U.S. Digital Service, and written in language that technology start-ups with no prior government experience can understand.
 - The playbook should be aggressively publicized to increase its visibility.
- **Bridge public and private investment through the Small Business and Innovation Research (SBIR) Program.⁸⁴**
 - Support agency efforts to modernize SBIR to more effectively develop and deploy AI solutions and encourage broader participation of American technology start-up and small business companies (see below).
 - Expand pilot programs that offer supplemental funding to bridge the gap between current SBIR/STTR Phase II awards and Phase III scaling efforts⁸⁵

⁸³ The Consolidated Appropriations Act, 2021, outlines AI CoE’s duties to include “(1) regularly convening individuals from agencies, industry, Federal laboratories, nonprofit organizations, institutions of higher education, and other entities to discuss recent developments in artificial intelligence, including the dissemination of information regarding programs, pilots, and other initiatives at agencies, as well as recent trends and relevant information on the understanding, adoption, and use of artificial intelligence; (2) collecting, aggregating, and publishing on a publicly available website information regarding programs, pilots, and other initiatives led by other agencies and any other information determined appropriate by the Administrator.” *Rules Committee Print 116-68, Text of the House Amendment to Senate Amendment to H.R. 133*, U.S. House Committee on Rules at 378-79 (Dec. 21, 2020), <https://rules.house.gov/sites/democrats.rules.house.gov/files/BILLS-116HR133SA-RCP-116-68.pdf>.

⁸⁴ The SBIR program is one of the largest and longest standing programs for federally funded R&D in small businesses. Established in 1982 as part of the Small Business Innovation Development Act, Federal agencies with extramural research and development budgets that exceed \$100 million set aside 3.2 percent of their budgets to fund the SBIR program. The program is structured in three phases: Phase I awards of approximately \$50,000 - \$250,000 for six months to vet “technical merit, feasibility, and commercial potential;” Phase II awards of \$750,000-\$1,700,000 for two years to support successful efforts initiated in Phase I; and Phase III, which is not funded by SBIR dollars, to pursue commercialization. The program issues a higher number of Phase I awards but allocates more funding towards Phase II, with the goal of placing many small bets on novel technologies and only scaling those that show real promise. NSCAI Engagement (Sept. 25, 2020); see also *About*, Small Business Innovation Research (last accessed Feb. 3, 2021), <https://www.sbir.gov/about>.

⁸⁵ For example AFWEX’s Supplemental Funding Pilot Program (TACFI and STRATFI) and USD(R&E)’s Accelerated Transition (AT) funding program.

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- Expand pilot programs that offer larger funding amounts⁸⁶ and private-sector matching opportunities to support higher technology readiness levels common in DoD SBIR contracts.⁸⁷
- Update SBIR Policy Directive to allow programs to require matching private sector funds as early as Phase II.⁸⁸

Actions for Department of Defense and Intelligence Community:

- **Adopt a “hoteling” model to allow small- and medium-sized technology companies to access classified facilities on a flexible basis.**
 - The Digital Ecosystem described in Chapter 2 of this report would establish prototypical platform environments for contributors and users, including cleared personnel from AI companies. Flexible access to classified spaces would speed development cycles and help companies more regularly engage with current or potential customers within the national security enterprise, leading to more tailored and effective solutions delivered more quickly.
- **Simplify the contracting process to attract non-traditional vendors.**
 - Amend the Defense Federal Acquisition Regulation to allow commercial performance to be considered more widely in the contracting process. The U.S. government can benefit from broader adoption of best in-class commercial AI software. Allow for pilot use of commercially available, digital application tools and access portals for SBIR and other non-traditional contracting vehicles.⁸⁹
- **Commit to growing the national security innovation base.**
 - DoD should set a target of increasing its contracts with early-stage technology firms by four times over the five-year Future Years Defense Program.⁹⁰ This will

⁸⁶ “As of November 2020, agencies may issue a Phase I award (including modifications) up to \$259,613 and a Phase II award (including modifications) up to \$1,730,751 without seeking SBA approval. Any award above those levels will require a waiver.” *About, Small Business Innovation Research* (last accessed Feb. 3, 2021), <https://www.sbir.gov/about>. See also *Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) Program Policy Directive*, U.S. Small Business Association (May 2, 2019), https://www.sbir.gov/sites/default/files/SBIR-STTR_Policy_Directive_2019.pdf.

⁸⁷ The Air Force, in partnership with Air Force Research Lab (AFRL), and the National Security Innovation Network (NSIN), developed Open SBIR Topics (which includes a “few big bets” (Strategic Financing): rewards of up to \$15 million, with 1:1:2 Program-SBIR-Private Matching options. *SBIR Open Topics*, U.S. Air Force AFWERX (last accessed Feb. 3, 2021), <https://www.afwerx.af mil/sbir.html>.

⁸⁸ Specifically, on page 74 of the SBA SBIR/STTR Policy Directive, the line “For example, some agencies administer Phase IIB awards that differ from the base Phase II in that they require third party matching of the SBIR/STTR funds.” could be changed to “For example, some agencies administer Phase II or IIB awards that require third party matching of the SBIR/STTR funds.” *Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) Program Policy Directive*, U.S. Small Business Administration at 74 (May 2, 2019), https://www.sbir.gov/sites/default/files/SBIR-STTR_Policy_Directive_2019.pdf.

⁸⁹ The current application portals for beta.sam.gov and the “Defense SBIR/STTR Innovation Portal” (DSIP) are significant barriers to entry for non-traditionals trying to work with the government. NSCAI staff engagement (Feb. 9, 2021).

⁹⁰ *Future of Defense Task Force Report 2020*, U.S. House Committee on Armed Services at 68 (Sept. 23, 2020),

https://armedservices.house.gov/cache/files/2/6/26129500-d208-47ba-a9f7-25a8f82828b0/424EB2008281A3C79BA8C7EA71890AE9_future-of-defense-task-force-report.pdf.

also require growing the budgets of successful but nascent innovation programs such as the Defense Innovation Unit.

- To this point, DoD has focused on a large number of small bets without following up with larger later stage investments. Larger contracts for later stage companies would help scale validated solutions that meet military requirements.
- USD(A&S) and the Service Acquisition Executives should encourage Acquisition Category (ACAT) programs of all sizes to solicit bids from at least 1 non-traditional contractor per program.
- **Strengthen return on SBIR investments.**
 - Review, modernize, and streamline SBIR processes to encourage broader participation of American technology start-up and small business companies.⁹¹
 - Program Officers should communicate pathways to transition, including milestone criteria and dollar amounts, clearly to SBIR awardees so that they can plan and resource accordingly.
 - Explicitly allow SBIR contracts to leverage any ‘color of money’ as matching funds up to the amount of SBIR funding.
 - Enable successful prototypes to scale through sufficient funding, early access to customers and operators, and better due diligence on the commercialization prospects of a company.⁹²
 - Service and OSD SBIR programs should allocate a portion of SBIR funding for scaling successful SBIR projects through Phase II enhancements.⁹³
 - Program Offices should provide program dollars alongside matching SBIR funds to increase the likelihood of transition.
 - Continue efforts to align SBIR program with technology priorities to focus investments on subsets of key technologies on which private sector R&D can help advance.⁹⁴
 - The Office of the Undersecretary of Defense for Research and Engineering should introduce a special solicitation on AI that invites

⁹¹ Contracts must be easier to understand and fill out, review periods shortened and clearly communicated, and oversight streamlined to keep pace with the current rate of technology innovation.

⁹² Phase II and supplemental awards should be based on a broader diligence process that includes the long-term health and viability of the company. This assessment should consider as a starting point the firm’s technical capabilities, financial structure, management structure, and the larger commercial market opportunities.

⁹³ Phase II enhancements, sometimes called Phase IIB/II.5 contacts, have become a common method to extend SBIR dollars to promising projects that fail to secure Phase III funding. The Navy Commercialization Readiness Program oversees the distribution of Phase II.5 contracts “to further develop SBIR technologies and to accelerate transition for existing Phase II projects.” *Navy Phase II.5 Structure and CRP*, U.S. Navy, (last accessed Feb. 3, 2021), <https://www.navysbir.com/cpp.htm>. The Air Force’s AFWERX, Army, and DARPA, as well as several Federal agencies outside the DoD, also use Phase IIB awards. The Office of the Secretary of Defense (OSD) Transitions SBIR Technology (OTST) Pilot Program provides SBIR awardees the opportunity to apply for Phase II Enhancement (e) and Accelerated Transition (AT) funding for the funding sponsor. However, current funding limits set by SBA reduce their efficacy by including Phase II enhancements under the Phase II cap of SBIR dollars. NSCAI staff engagement (Sept. 23, 2020). For further detail, see *Interim Report and Third Quarter Recommendations*, NSCAI at 52-57 (Oct. 2020), <https://www.nscai.gov/previous-reports/>.

⁹⁴ This effort would be informed by the technology annex to the National Defense Strategy recommended in Chapter 2 of this report.

solutions across a diversity of AI approaches⁹⁵ and a range of technology readiness levels.⁹⁶

Component 2: Form a Network of Regional Innovation Clusters Focused on Strategic Emerging Technologies

Competition is critical to a vibrant national security innovation base.⁹⁷ If a strategic industry lacks competition, one wrong bet by an incumbent can place the nation's technological leadership in jeopardy.⁹⁸ The U.S. government should create an environment in which innovative startups are able to disrupt inefficient or outdated ways of doing business and grow into industry leaders themselves. The right mix of policies and incentives can help firms overcome mounting barriers to entry at the cutting edge of emerging technologies like AI.⁹⁹ This approach will promote innovation in industries that are essential to U.S. leadership in AI and the nation's economic and technological competitiveness more broadly.¹⁰⁰

As the Commission noted in its *2019 Interim Report*, the clustering of technology firms in regions like Silicon Valley yields a more dynamic and globally competitive industry by expediting knowledge sharing and sharpening domestic rivalry.¹⁰¹ However, this trend has benefited some regions and demographics more than others.¹⁰² To spur regional innovation across a broader swath of the nation, the U.S. government should support the growth of technology clusters in regions with latent innovation potential. Broader in mission and scope than existing models within the U.S. government, such an initiative would democratize access to federal R&D resources so that small firms could compete in industries with high barriers to entry like AI. By facilitating the exchange of technology and talent between the public and private sectors, the U.S. government would also be well positioned to establish new contracts and intellectual property sharing agreements for commercial technologies that are critical to U.S. national security.

Actions for Congress:

⁹⁵ The future will likely be defined by a fusion of many different AI approaches including expert systems, model based AI, symbolic-based AI, statistical machine learning, and new and evolving AI approaches such as neurosymbolic AI. See *Neuro Symbolic AI*, MIT-IBM Watson AI Lab (last accessed Feb. 3, 2020), <https://mitibmwatsonailab.mit.edu/category/neuro-symbolic-ai/>.

⁹⁶ DARPA's SBIR program, for example, is unique in its long time horizon. Most of its investments are pre-commercial and will take another 8-10 years to develop before results can be scaled for military or commercial use.

⁹⁷ David E. Cooper, *Defense Industry Consolidation: Competition Effects of Mergers and Acquisitions*, Statement before the U.S. Senate Committee on Armed Services Subcommittee on Acquisition and Technology (Mar. 4, 1998), <https://www.gao.gov/assets/110/107240.pdf>.

⁹⁸ For example, Intel's recent chip missteps have jeopardized U.S. leadership in the design and manufacturing of advanced semiconductors. See Michael Kan, *Intel: Sorry, but Our 7nm Chips Will be Delayed to 2022, 2023*, (July 23, 2020), <https://www.pcmag.com/news/intel-sorry-but-our-7nm-chips-will-be-delayed-to-2022-2023>.

⁹⁹ For example, small firms have difficulty affording the cost of compute resources and data for training sophisticated machine learning (ML) models. Nur Ahmed & Muntasir Wahed, *The De-democratization of AI: Deep Learning and the Compute Divide in Artificial Intelligence Research*, arXiv (Oct. 22, 2020), <https://arxiv.org/abs/2010.15581>.

¹⁰⁰ Michael Porter, *The Competitive Advantage of Nations*, Harvard Business Review (1990), <https://hbr.org/1990/03/the-competitive-advantage-of-nations>.

¹⁰¹ *Interim Report*, NSCAI at 26 (Nov. 2019), <https://www.nscai.gov/previous-reports/>; see also Michael Porter, *Clusters and the New Economies of Competition*, Harvard Business Review (1998), <https://hbr.org/1998/11/clusters-and-the-new-economies-of-competition>.

¹⁰² William R. Kerr & Frederic Robert-Nicoud, *Tech Clusters*, Journal of Economic Perspectives at 63 (2020), <https://pubs.aeaweb.org/doi/pdfplus/10.1257/jep.34.3.50>.

- **Establish an interagency program office responsible for coordinating a network of regional innovation clusters focused on the research, development, and commercialization of strategic emerging technologies.**
 - The program office should be hosted by the Department of Commerce at NIST and staffed by representatives from U.S. departments and agencies with experience in and missions related to strategic emerging technologies.¹⁰³ The program office should also draw on expertise from the private sector and academia through talent exchange programs and external advisory arrangements.
 - Congress should authorize \$5 million for the creation of the program office and task it with designating regional innovation clusters in qualified locations throughout the United States via a competitive process, as described below in detail. As a first step, the program office should solicit bids for financial assistance from applicants focused on the research, development, and commercialization of strategic emerging technologies. In assessing bids, the program office should consider the following criteria:
 - *Location.* Clusters should be equitably distributed throughout the United States in regions with latent innovation potential, taking into account factors such as proximity to federal research and development facilities, the level of support from state and local governments, the presence of and value proposition for leading firms and research institutions, and the size and education level of the local workforce.¹⁰⁴
 - *Subject area.* Clusters should be organized around the research, development, and commercialization of strategic emerging technologies that are critical to U.S. national competitiveness. Of particular interest are technologies that enable advances in adjacent sectors and whose domestic production would directly benefit U.S. national security, such as microelectronics.¹⁰⁵
 - *Economic feasibility.* To maximize the impact of federal resources and ensure self-sustainability of the clusters, financial assistance should only be awarded to applicants that demonstrate the existence of a nascent cluster in their region.¹⁰⁶
 - The program office should establish Technology Research Centers (TRCs) for each cluster to facilitate collaboration between participants. By forming sustained

¹⁰³ The program office could be modeled on the Advanced Manufacturing National Program Office that coordinates Manufacturing USA, a network of manufacturing innovation institutes. See Manufacturing USA (last accessed Feb. 3, 2021), <https://www.manufacturingusa.com/>.

¹⁰⁴ For example, proximity to research facilities operated by the Departments of Defense and Energy or access to technically oriented military installations should be prioritized.

¹⁰⁵ See the Commission's *First Quarter Recommendations* on the importance of U.S. access to trusted and assured microelectronics for national security use cases. *First Quarter Recommendations*, NSCAI at 46-49 (Mar. 2020), <https://www.nsc.ai.gov/previous-reports/>.

¹⁰⁶ The existence of a nascent cluster suggests industry has already passed the market test. Mark Muro & Bruce Katz, *The New "Cluster Moment": How Regional Innovation Clusters Can Foster the Next Economy*, The Brookings Institution (Sep. 21, 2010), <https://www.brookings.edu/research/the-new-cluster-moment-how-regional-innovation-clusters-can-foster-the-next-economy/>. Resources like the U.S. Cluster Mapping Project will also be essential to identify which locations are economically viable. See US Cluster Mapping (last accessed Feb. 3, 2021), <http://clustermapping.us/>.

partnerships with anchor institutions, each TRC should strive to advance the research, development, and commercialization of strategic emerging technologies.¹⁰⁷

- *Leverage talent.* TRCs should host researchers on temporary assignments from U.S. departments and agencies, establish talent exchanges with local firms and research institutions, and fund multi-year, post-doctoral fellowships for the commercialization of research.¹⁰⁸
 - *Encourage technology transfer.* TRCs should host program managers from U.S. departments and agencies responsible for transitioning basic research into commercially viable technologies, identifying national security use cases and end users within the U.S. government, and initiating new government contracts for those products.
 - *Generate intellectual property.* TRCs should establish intellectual property sharing agreements with cluster participants to encourage government adoption of commercial technologies. When appropriate, research should be published in the open-source domain to encourage advances in the broader science and technology community.
 - *Bring government resources to bear.* TRCs should facilitate participants' access to federal computing resources, curated government datasets, testing infrastructure and ranges, and other R&D facilities at low cost.¹⁰⁹
 - The program office should play a high-level coordination role that includes supervising the operation of TRCs, facilitating research and development collaboration between clusters, and promoting the commercialization of technologies with national security use cases.
- **Enact a package of provisions that incentivizes industry and academia to participate in clusters.**
 - Provisions should include tax incentives to locate near the cluster, competitive research grants, loan guarantees, and seed funding. A complementary approach should be taken by state and local governments. These policies could be modeled on Opportunity Zones, which have stimulated investment in regional economies.¹¹⁰
 - *Investment tax credits.* To compete with incentives offered by foreign countries, Congress should establish investment tax credits for firms participating in regional innovation clusters. While the details of these tax

¹⁰⁷ Anchor institutions are firms, not-for-profit institutions, and research universities that locate near the cluster and pursue joint R&D with federal agencies or other cluster participants.

¹⁰⁸ *Overview: The New Federal Role in Innovation Clusters, Clustering for 21st Century Prosperity: Summary of a Symposium*, The National Academies Press (2012), <https://www.nap.edu/read/13249/chapter/3#31>.

¹⁰⁹ For example, the clusters may be co-located with DoE's national laboratories or military test ranges.

¹¹⁰ According to the Council of Economic Advisors, Opportunity Zones (OZs) incentivize private investment in low-income communities by lowering capital gains taxes on businesses investing in the region, which could be a revenue neutral way of lifting people out of poverty due to the expected reduction in transfer payments. Investors receive tax benefits for investing in Qualified Opportunity Funds, which can be used to make equity investments in partnerships or corporations that operate in an OZ. The funds can also be used to purchase tangible property for use in the fund's trade or business. See *The Impact of Opportunity Zones*, The Council of Economic Advisors (Aug. 2020), <https://trumpwhitehouse.archives.gov/wp-content/uploads/2020/08/The-Impact-of-Opportunity-Zones-An-Initial-Assessment.pdf>.

credits will vary by sector, one example is the semiconductor investment tax credit proposed in the Commission's *Third Quarter Recommendations*.¹¹¹

- **Provide funding to each cluster for at least five years, with matching investments from public and private sector partners.**
 - Within one year, the program office should request from Congress the necessary funding for the designation of up to 10 clusters. This funding should be matched at least 1:1 by investment from private companies, state and local governments, and federal agencies, with a target of each cluster initially receiving a total of \$50 million annually. This annual amount should increase as demand and capacity at each cluster expands over time.¹¹² These funds would be used to operate the TRCs, maintain R&D facilities, issue research grants, and seed startups.

Component 3: Establish a Private Sector-led Competitiveness Consortium

The private sector shares responsibility with the government to strengthen the foundations of the R&D ecosystem that underpins breakthroughs they will commercialize and the training pipeline needed to meet their increasing demand for technical talent.

Companies are already struggling to find these qualified applicants for technical roles, with one estimate showing over 400,000 open computing jobs nationwide.¹¹³ Furthermore, as described above, researchers in academia who will undertake the high-risk, high-gain research that will push the frontiers of the field are finding themselves locked out from the computing and data resources needed to fuel this work. How well the nation addresses this looming challenge has widespread implications for the economy, society, and U.S. global competitiveness.

Chapter 10 of this report describes in detail recommendations to revamp the U.S. educational system to equip Americans for the jobs of the future and this chapter details the extensive investments the Federal Government should make in AI R&D. However, corporations should also consider their responsibility to prepare citizens for the future they are inventing and maintain the strong foundation of national innovation from which they benefit. Toward that end, many firms are already having a positive impact beyond their bottom lines through corporate social responsibility efforts. STEM education programs and job training feature prominently in the charitable giving arms of leading tech firms.¹¹⁴ Yet the scale of the challenge is too broad for individual firms to address in isolation, despite their generosity.

¹¹¹ See Recommendation 3.2 in the Commission's *Third Quarter Recommendations. Interim Report and Third Quarter Recommendations*, NSCAI at 166-167 (Oct. 2020), <https://www.nsc.ai.gov/previous-reports/>.

¹¹² Private sector contributions may comprise cost sharing in joint R&D projects, donations, or membership dues, if such a model is adopted.

¹¹³ CODE Advocacy Coalition (last accessed Jan. 2, 2021), <https://advocacy.code.org/>.

¹¹⁴ See e.g., *Microsoft Philanthropies: TechSpark*, <https://query.prod.cms.rt.microsoft.com/cms/api/am/binary/RE4s6AL>; Carolina Milanesi, *STEM Education as a Diversity Driver in Tech*, Amazon (Sept. 14, 2020), <https://www.aboutamazon.com/news/community/stem-education-as-a-diversity-driver-in-tech>; *Applied Digital Skills: Teach and Learn Practical Digital Skills*, Google (last accessed Jan. 2, 2021), <https://applieddigitalskills.withgoogle.com/s/en/home>.

Actions for the Private Sector:

- **Donate \$1 billion over five years.**
 - Providing every American an opportunity to increase their technical proficiency requires bold action from government, academia, and industry to coordinate, prioritize, and scale programs that broaden AI research opportunities and instill digital proficiency.¹¹⁵ For the private sector to meet this call to action, the Commission calls upon industry to donate \$1 billion over the next five years to support AI education and upskilling, and provide data and compute resources to democratize and fuel best-in-class AI research efforts.
 - These funds would lay the foundation for broader digital transformation and economic empowerment. Government officials should publicly highlight the impact of this effort and the role of the firms contributing to it.
 - Similar to the Partnership on AI's work coordinating development of best practices across AI firms,¹¹⁶ this effort should be managed by an independent non-profit organization that can link and scale firms' efforts to build digital skills and democratize AI research. The U.S. Digital Service Academy could also contribute expertise, volunteers, curriculum development, and other in-kind support.¹¹⁷
- **Expand research exchanges between industry and academia**
 - Leading technology firms should invest in or expand exchange programs designed to combine top academic talent with world class private sector computing resources. Rotational exchanges of this type would both democratize computing access for researchers and simultaneously shed light on new pathways for next generation AI products that could be commercialized by industry.

Action for the U.S. Bureau of Labor Statistics:

- **Standardize and report data on digital skills in the job market.**
 - The U.S. Bureau of Labor Statistics should lead an effort in coordination with other agencies such as the Department of Education to collect and regularly update statistics on the digital proficiency of demographic groups and regions, with entries describing specific digital skills needed by firms with job openings. This will enable academic institutions, firms, and other organizations to prioritize their efforts for educating, reskilling, upskilling, and digital transformation.

Recommendation: Tackle Some of Humanity's Biggest Challenges

¹¹⁵ Michael Wade, *Corporate Responsibility in the Digital Era*, MIT Sloan Management Review (Apr. 28, 2020), <https://sloanreview.mit.edu/article/corporate-responsibility-in-the-digital-era/>.

¹¹⁶ Partnership on AI has a mission to shape best practices, research, and public dialogue about AI's benefits for people and society, with partners from more than 100 companies and research organizations. *Partnership on AI* (last accessed Feb. 3, 2021), <https://www.partnershiponai.org>.

¹¹⁷ See Chapter 6 of this report for further discussion of the Commission's proposed U.S. Digital Service Academy.

If the investments detailed above are implemented, they will set the conditions to harness AI to tackle some of the biggest challenges in science, society, and national security.

Examples of promising initiatives that could improve societal well-being and advance scientific frontiers include, but are not limited to:

- *Enable long term quality of life.* AI technology that can help the elderly live independently longer, assisting in managing health and daily tasks, and improving the quality of life. This can include application of AI to biomedicine to address acute and chronic illnesses and enhance healthy aging.
- *Revolutionize education and life-long learning.* AI tools that personalize education, training, and retraining at appropriate challenge levels and intuitively evaluate development to optimize standard curricula to promote individual learning success.
- *Transform energy management.* Smart infrastructure for cities that can effectively respond to surges in energy demand and emergencies (both man-made and natural disasters).
- *Effectively predict, model, prepare for and respond to disasters.* Accurate, near real time weather, earthquake, and fire line detection and prediction of escalation to aid in emergency response and planning for optimized deployment of limited resources. Autonomous robots for search, rescue, and clean up in the wake of natural or man-made disaster, providing force-multiplying support to first responders and hazardous materials professionals.

Action for the Office of Science and Technology Policy:

- **Direct the National AI Initiative to align federal investments in AI R&D to tackle significant scientific, technological, and societal challenges.**
 - The National AI Initiative should identify and oversee realization of opportunities to harness federal R&D investments to take on audacious scientific and technological challenges that could lead to breakthroughs that benefit society and national security.¹¹⁸
 - Prioritization of these efforts should be coordinated with the national security research community and informed by the Technology Competitiveness Council,¹¹⁹ to define areas of research where the application of AI could contribute to progress that provides strategic advantages.

¹¹⁸ One way this could be enacted is by assigning “national mission managers” to oversee each opportunity identified.

¹¹⁹ As recommended in Chapter 9 of this report.

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Chapter 12: Intellectual Property

Blueprint for Action

America's intellectual property (IP) laws and institutions must be considered as critical components for safeguarding U.S. national security interests, including advancing economic prosperity and technology competitiveness. Prioritization of IP policy is especially important given China is both leveraging and exploiting IP policies as a tool within its national strategies for emerging technologies. The United States must, at minimum, articulate and develop national IP reforms and policies with the goal of incentivizing, expanding, and protecting AI and emerging technologies,¹²⁰ at home and abroad. Such policies should be developed and proposed via the Executive Branch with a process that integrates the disparate departments and agencies that serve important roles in promoting U.S. innovation.

Recommendation: Develop and implement national IP policies and regimes to incentivize, expand, and protect AI and emerging technologies as part of national security strategies.

Action for the President:

- **Issue an Executive Order to prioritize IP policies for AI and critical emerging technologies.**
 - The President should issue an Executive Order to recognize IP policy as a national priority and establish a comprehensive process to reform and establish new IP policies and regimes for AI and critical emerging technologies that further national security, economic, and technology competitiveness strategies.
 - The E.O. should:
 - Direct the Vice President, as Chair of the Technology Competitiveness Council (TCC)¹²¹ or otherwise as chair of an interagency task force,¹²² to oversee the comprehensive process;
 - Direct the Secretary of Commerce to:
 - Lead, on an ongoing basis, the development of proposals (executive and/or legislative branch actions) to reform and establish new IP policies and regimes to incentivize, expand, and protect AI and emerging technologies;
 - In executing these responsibilities, coordinate with the Under Secretary of Commerce for Intellectual Property and Director of the U.S. Patent and Trademark Office (USPTO) and other relevant

¹²⁰ For a discussion of the U.S. government's efforts to define and prioritize critical emerging technologies as well as the Commission's recommended eight emerging technologies key to U.S. national competitiveness, see Chapter 16 of this report and its Blueprint for Action.

¹²¹ NSCAI recommended the creation of a Technology Competitiveness Council in its 2020 Interim Report and Third Quarter Recommendations. See *Interim Report and Third Quarter Recommendations*, NSCAI at 180 (Oct. 2020), <https://www.nscai.gov/previous-reports/> ("Technology Competitiveness Council, led by the Vice President and with a Commissioned Assistant to the President as the day-to-day coordinator, to fill this role.") If the TCC is not established as recommended by the Commission, the Commission recommends that the Vice President should lead these efforts.

¹²² If the TCC is not established, the President, through an Executive Order, should establish a task force to address the mandate recommended here.

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Executive Branch agencies, consult with the Director of the U.S. Copyright Office, and convene public deliberations, to include at a minimum academia and industry;

- Direct the USPTO Director, in his capacity as advisor to the President,¹²³ to:
 - Submit, within 90 days, a report to the Vice President, in their capacity as the head of the TCC or interagency task force, that: (1) identifies and analyzes metrics, trends, and data¹²⁴ necessary to inform IP policy making, particularly as prioritized in the Executive Order, and (2) identifies the associated U.S. Executive Branch departments and agencies that will be required to provide any requisite data;
 - Submit, within 12 months from issuance of the first report, a second report, or portions on a rolling basis, to the Vice President that: (1) comprehensively assesses the weaknesses in the current U.S. IP policies and regimes, relative to IP regimes of other nations, for incentivizing, expanding, and protecting innovation in AI and emerging technologies and supporting national strategies; (2) examines the non-exhaustive list of “IP considerations (see second recommendation); and (3) proposes corresponding executive and legislative actions for reforming and establishing new IP policies and regimes;
 - Provide all necessary information and advice to the Vice President to enable a fulsome analysis of the IP proposals;
- Direct the Vice President to:
 - Lead an ongoing assessment of IP policies, regimes, and reform proposals from the Secretary of Commerce that should be implemented and integrated into national security, economic, and technology competitiveness strategies;
 - Empower the Secretary of Commerce to facilitate implementation of IP policies and regimes assessed as critical to national security, economic, and technology competitiveness strategies; and

¹²³ The USPTO Director “shall advise the President, through the Secretary of Commerce, on national and certain international intellectual property policy issues.” 35 U.S.C. § 2.

¹²⁴ Due to the breadth of the IP considerations, including those delineated in this report, as well as the far-reaching impact of IP upon many segments of the U.S. economy and innovation ecosystem, there are many U.S. government entities that may already track relevant metrics or have the capability to expand their analyses to address the necessary prioritization of IP for AI and emerging technologies. For example, innovation trends based on patent filings, and where possible, licensing data—in various technology sectors, including by foreign countries, particularly China, should be analyzed (e.g., to assess quality and research trends#), with care not to rely solely on patent counting. Other potential metrics include, but are not limited to: tracking of patents self-declared as standard essential in comparison to patents actually licensed; licensing to unrelated parties; the impact of prior art on the U.S. patent and trademark examination systems; international filings for IP protections on U.S.-funded research, particularly without U.S. funders’ or inventors’ awareness; the ratio of U.S. companies filing for IP protections in the U.S. versus abroad; and patent assignment data. If necessary, the Office of the Vice President/TCC should work with U.S. government departments and agencies to ensure the Secretary of Commerce has consistent, regular access to these metrics. As an example, an examination of China’s patents can provide insight into its biotechnology and genomics research and plans. See Kristy Needham, *Exclusive: China Gene Firm Providing Worldwide COVID Tests Worked with Chinese Military*, Reuters (Jan. 30, 2021), <https://www.reuters.com/article/us-china-genomics-military-exclusive/exclusive-china-gene-firm-providing-worldwide-covid-tests-worked-with-chinese-military-idUSKBN29Z0HA>.

- Direct Executive Branch departments and agencies to resource and support the Secretary of Commerce in executing these Executive Order efforts, including providing the identified metrics and trends.

Action for the Secretary of Commerce and USPTO Director:

- **Establish, as necessary, in consultation with the Director of the USPTO, a committee of multidisciplinary experts, from within and outside the U.S. government, to provide technical and IP-related expertise and advice in implementing this Executive Order.**
- **Convene public deliberations, to include at a minimum academia and industry, in executing these executive order responsibilities. The outcome of these deliberations should inform proposed IP policies and regimes.**
- **Assess metrics and data necessary to inform IP policy.**
 - In assessing the proper metrics and data necessary to inform IP policy deliberation as required by the executive order, the Secretary of Commerce and USPTO Director should take a whole of government approach. Due to the breadth of the IP considerations, including those delineated in this report, as well as the far-reaching impact of IP upon many segments of the U.S. economy and innovation ecosystem, there are many U.S. government entities that may already track relevant metrics or have the capability to expand their analyses to address the necessary prioritization of IP for AI and emerging technologies.
 - For example, innovation and investment trends based on patent filings, and where possible, licensing data—in various technology sectors, including by foreign countries, particularly China, should be analyzed (e.g., to assess quality and research trends¹²⁵), with care not to rely solely on patent counting.
 - Other potential metrics include, but are not limited to: tracking of patents self-declared as standard essential in comparison to patents actually licensed; licensing to unrelated parties; the impact of prior art on the U.S. patent and trademark examination systems; international filings for IP protections on U.S.-funded research, particularly without U.S. funders' or inventors' awareness; the ratio of U.S. companies filing for IP protections, as well as pursuing IP-related litigation, in the U.S. versus abroad; and patent assignment data.

¹²⁵ As an example, an examination of China's patents can provide insight into its biotechnology and genomics research and plans. See Kristy Needham, *Exclusive: China Gene Firm Providing Worldwide COVID Tests Worked with Chinese Military*, Reuters (Jan. 30, 2021), <https://www.reuters.com/article/us-china-genomics-military-exclusive/exclusive-china-gene-firm-providing-worldwide-covid-tests-worked-with-chinese-military-idUSKBN29Z0HA>.

Action for the Department of Justice:

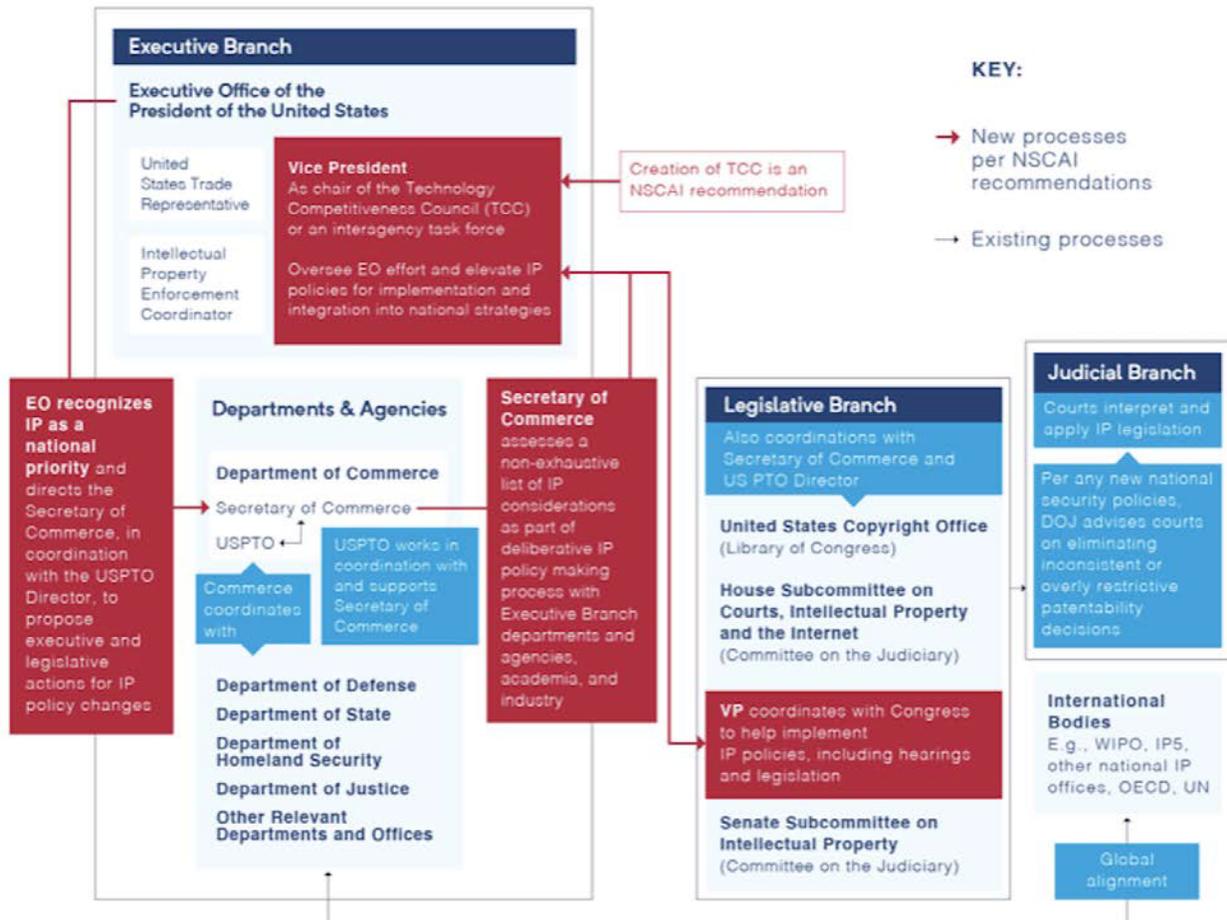
- **Advise courts on ensuring consistency on patentability decisions.**
 - The Department of Justice through the Solicitor General and the Civil Appellate Section, should advise federal courts on eliminating confusing, inconsistent, or overly restrictive patentability decisions to ensure consistency with national security policies.

Action for Congress:

- **Prioritize proposed IP-related legislation to bolster U.S. national strategies, including for national security, economic interests, and technology competitiveness.**
 - Congress should prioritize legislative recommendations for IP policies and regimes elevated by the Vice President, as Chair of the TCC or an interagency task force. This is particularly important given Congress is responsible for passing patent and IP legislation that the USPTO and other relevant stakeholders execute and follow. Additionally, the U.S. Copyright Office is housed as a federal department within the Library of Congress, as the principal advisor to Congress on copyright matters and administers copyright registrations.¹²⁶

¹²⁶ *Overview of the Copyright Office*, U.S. Copyright Office (last accessed Feb. 2, 2021), <https://www.copyright.gov/about/>.

Executive Order to Reform and Establish IP Policies and Regimes*



*This illustration is not comprehensive of all relevant U.S. government entities with intellectual property responsibilities

Recommendation: The Secretary of Commerce should assess and examine the following non-exhaustive list of “IP considerations,” in coordination with the Under Secretary of Commerce for IP and Director of the USPTO, as part of developing and proposing reforms and new IP policies and regimes to the Vice President.

Action for the Secretary of Commerce:

- **Assess and examine the following non-exhaustive list of 10 considerations for intellectual property as part of the Commission’s recommended reports submitted to the Vice President as part of the recommended Executive Order.**

1. Patent Eligibility: The Secretary of Commerce should assess and articulate the impact of current patent eligibility laws on innovation in AI and emerging technologies from an economic, trade, and national security policy perspective to better inform the legislative and agency efforts on patent eligibility reform. America’s IP regime has spurred American ingenuity since the late 18th century. By protecting “any new and useful process, machine, manufacture, or composition

of matter” through stable legal institutions governed by the rule of the law, inventors and investors relied on America’s IP system to provide the certainty necessary to justify large and risky R&D investments,¹²⁷ which are critical for technologies.¹²⁸ A strong and robust patent system is equally critical to incentivizing American innovation in AI and emerging technologies that affect national security.¹²⁹ Unfortunately, recent patent eligibility court rulings have narrowed the scope of inventions that are eligible for patent protection. This has resulted in a broad swath of innovation that is now ineligible for patent protection in both digital technologies and biopharma, among others.¹³⁰ The legal uncertainty for U.S. innovators and companies as to whether their inventions will be eligible for patent protection or susceptible to invalidation once granted is pervasive.¹³¹ This uncertainty in turn has impacted investments in AI and technologies

¹²⁷ NSCAI staff engagement with Professor Adam Mossoff, Antonin Scalia Law School, George Mason Univ. (Oct. 7, 2020); David J. Kappos, *National Security Consequences of U.S. Patent (In)eligibility*, Morning Consult (Nov. 4, 2019), <https://morningconsult.com/opinions/national-security-consequences-of-u-s-patent-ineligibility/>.

¹²⁸ For example, the Supreme Court’s controversial 1980 decision in *Diamond v. Chakrabarty*, which classifies genetically modified bacterium as a patentable innovation (under Section 101), “was a key factor in spurring the explosive growth in the biotech industry in the ensuing decade in the U.S. The *Chakrabarty* Court’s recognition that the products of biotech research are patentable, especially when such products are living organisms or represent the building blocks of life, paved the way for dramatic advances in the life sciences and in medical treatment, such as in cancer research.” While the U.S. was the first country to patent genetic modification of living organisms (critical for cancer research), other countries refused to patent such innovations for over a decade. This led the U.S. to be the birthplace of the biotech revolution. Similarly, the Supreme Court’s 1981 decision in *Diamond v. Diehr* that an invented process using “a computer program was not automatically an ‘abstract idea’ or ‘algorithm’ that precluded patent protection,” was key for providing reliable patent rights that enabled the high-tech revolution of the late 20th century. Kevin Madigan & Adam Mossoff, *Turning Gold to Lead: How Patent Eligibility Doctrine is Undermining U.S. Leadership in Innovation*, *George Mason Law Review* Vol. 24 at 942-946 (2017), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2943431 [hereinafter *Turning Gold to Lead*].

¹²⁹ Technology critical to national security interests include AI, microelectronics, 5G telecommunications, quantum computing, and biotechnology. For more information on various U.S. government efforts to define and prioritize critical emerging technologies and the Commission’s recommended list of critical emerging technologies, see Chapter 16 of this report and its Blueprint for Action. See also *Interim Report and Third Quarter Recommendations*, NSCAI at 138 (Oct. 2020), <https://www.nscai.gov/previous-reports/>. There also is a convergence of technologies with the infusion of AI across all technologies. See Joint Written Testimony of Dr. Eric Schmidt et al. before the H. Comm. on Armed Services, Subcomm. on Intelligence and Emerging Threats and Capabilities, *Interim Review of the National Security Commission on Artificial Intelligence Effort and Recommendations*, (Sept. 17, 2020), <https://docs.house.gov/meetings/AS/AS26/20200917/110996/HHRG-116-AS26-Wstate-SchmidtE-20200917.pdf>.

¹³⁰ See *Alice Corp. v. CLS Bank Int’l*, 134 S. Ct. 2347, 2360 (2014) (holding that a computer program for facilitating complex international financial transactions is an abstract idea and cannot be patented); see also *Ass’n for Molecular Pathology v. Myriad Genetics, Inc.*, 133 S. Ct. 2107, 2117 (2013) (holding that isolated DNA for laboratory and medical uses is an unpatentable natural phenomenon); *Mayo Collaborative Servs. v. Prometheus Labs., Inc.*, 566 U.S. 66, 72–73 (2012) (holding that a diagnostic medical treatment for an autoimmune disorder is an unpatentable discovery of a law of nature); *Bilski v. Kappos*, 561 U.S. 593, 609 (2010) (holding that a business method for hedging investment risk is an abstract idea and not a patentable invention); *Turning Gold to Lead*, at 946-952.

¹³¹ A former Chief Judge of the Federal Circuit lamented this uncertainty while testifying before the U.S. Senate Judiciary Committee’s Intellectual Property Subcommittee: “It is important for me, as a retired [Federal Circuit] judge, to acknowledge that the courts alone created this problem. . . . If I, as a judge with 22 years of experience deciding patent cases on the Federal Circuit’s bench, cannot predict outcomes based on case law, how can we expect patent examiners, trial judges, inventors and investors to do so?” See Testimony of Judge Paul R. Michel (ret.), U.S. Court of Appeals for the Federal Circuit, before the U.S. Senate Committee on the Judiciary, Subcommittee on Intellectual Property, *The State of Patent Eligibility in America: Part I* (June 4, 2019), <https://www.judiciary.senate.gov/imo/media/doc/Michel%20Testimony.pdf>. The U.S. Chamber of Commerce recently observed that uncertainty surrounding patent-eligible subject matter and the viability of biopharmaceutical companies’ business models is posing “an existential threat to the United States’ position as the undisputed global leader in biopharmaceutical innovation.” *Art of the Possible: U.S. Chamber International IP Index*, United States Chamber of Commerce, Global Innovation Policy Center at 10 (2020), https://www.theglobalipcenter.com/wp-content/uploads/2020/02/023881_GIPC_IP_Index_2020_FullReport_A_04b.pdf. The former Director of the USPTO similarly emphasized the importance of certainty to innovation in the U.S.: “[t]o ensure that our nation remains at the forefront of AI and other technologies, we must, among other things, provide a reliable and predictable legal framework to incentivize and protect innovation here at home.” See USPTO Responses to Questions for the Record by Senator Tillis, Hon. Andrei Iancu, Undersecretary of Commerce for Intellectual Property and Director of the U.S. Patent and Trademark Office, as Witness, U.S.

critical to national security. Empirical studies have proven that patents are causally linked to venture capital investments in startups, and, as a result, are causally linked to the success of startups.¹³² Recent reports, however, reveal that investments in patent-intensive U.S. startups and also large, established companies that develop critical technologies (e.g., computer hardware, semiconductors, medical devices and supplies, and pharmaceuticals and biotechnology) have declined relative to non-patent-intensive companies.¹³³ This is consistent with investors consistently reporting that patent eligibility is a key factor in their decisions whether to invest in a particular company's technologies or bring a new product to market.¹³⁴

Legislation appears to be the only practical means to reform patent eligibility doctrine. The Judiciary, specifically the Supreme Court, has indicated an unwillingness to revisit its decisions in the past decade that have created this fundamental problem in patent eligibility doctrine.¹³⁵ The USPTO has adopted a framework for assessing patent eligibility during the examination process of patent applications, which has had positive results in providing greater certainty to

Senate Committee on the Judiciary, Subcommittee on Intellectual Property, *Oversight of the U.S. Patent and Trademark Office* at 11 (hearing held Mar. 13, 2019, responses submitted Aug. 15, 2019),

<https://www.judiciary.senate.gov/imo/media/doc/lancu%20Responses%20to%20QFRs2.pdf>.

¹³² See Joan Farre-Mensa, et al., *What Is a Patent Worth? Evidence from the U.S. Patent "Lottery,"* National Bureau of Economic Research (Dec. 2018), <https://www.nber.org/papers/w23268> (finding an almost double increase in chance of startup receiving venture capital investments if it has a patent, and further finding this causally linked to higher rate of success in startups); Stuart J.H. Graham, et al., *High Technology Entrepreneurs and the Patent System: Results of the 2008 Berkeley Patent Survey*, *Berkeley Technology Law Journal*, Vol. 24, No. 4 at 255-327 (Jul. 4, 2009), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=142904.

¹³³ Surveys and industry reports demonstrate that "investment has shifted away from patent-intensive industries." Mark F. Schultz, *The Importance of an Effective and Reliable Patent System to Investment in Critical Technologies*, Alliance for U.S. Startups and Investors for Jobs at 24-37 (July 2020), <https://static1.squarespace.com/static/5746149f86db43995675b6bb/t/5f2829980ddf0c536e7132a4/1596467617939/USIJ+Full+Report+Final+2020.pdf>. For example, a look at a subset of patent-reliant technologies (core internet networking, wireless communications, internet software, operating system software, semiconductors, pharmaceuticals, drug discovery, surgical devices, and medical supplies) shows a significant decrease in funding from 21% of total venture capital funding in 2004 to only 3.2% in 2017. *U.S. Startup Company Formation and Venture Capital Funding Trends 2004 to 2017*, Alliance for U.S. Startups and Investors for Jobs at 9 (June 2019), <https://static1.squarespace.com/static/5746149f86db43995675b6bb/t/5d14b7bb46692200012463e0/1561638845187/USIJ+U.S.+Startup+Formation+Trends+--+2014-2017.pdf>.

¹³⁴ David Taylor, *Patent Eligibility and Investment*, *Cardozo Law Review* at 2055-56 (2020), <http://cardozolawreview.com/patent-eligibility-and-investment/>.

¹³⁵ See e.g., *Hikma Pharmaceuticals USA Inc. v. Vanda Pharmaceuticals Inc.*, No. 18-817 (Jan. 13, 2020) (cert. denied); *Athena Diagnostics, Inc. v. Mayo Collaborative Servs., LLC*, No. 19-430 (Jan. 13, 2020) (cert. denied); *HP Inc. v. Berkheimer*, No. 18-415 (Jan. 13, 2020) (cert. denied). In *Athena*, all 12 active Judges of the Federal Circuit, the appellate court from which the decision was appealed to the Supreme Court, agreed that the diagnostic methods at issue should be patent eligible, but the majority indicated that they had to find the inventions ineligible for patent protection pursuant to Supreme Court precedent. *Athena Diagnostics, Inc. v. Mayo Collaborative Servs., LLC*, No. 19-430 (Jan. 13, 2020) (cert. denied). On January 29, 2021, however, the Supreme Court asked for a response to a petition for certiorari appealing a decision from the Federal Circuit that a drive shaft is not eligible for patent protection because the alleged invention is based on a natural law. *American Axle & Manf. Inc. v. Neapco Holdings LLC*, No. 20-891 (Jan. 29, 2021). See also Rebecca Lindhorst, *Two-Stepping Through Alice's Wasteland of Patent-Eligible Subject Matter: Why the Supreme Court Should Replace the Mayo/Alice Test*, *Case Western Reserve Law Review* at 759 (2019), <https://scholarlycommons.law.case.edu/cgi/viewcontent.cgi?article=4813&context=caselrev>.

patent applicants,¹³⁶ but the Federal Circuit does not seem inclined to follow USPTO guidance.¹³⁷

Efforts to reform the patent eligibility doctrine by amending the relevant provision in the patent statutes failed in 2019.¹³⁸ Efforts continue to restart the legislative reform process. A national security point of view has not been expressed on the impact of patent eligibility law on technologies critical to national security, such as artificial intelligence, microelectronics, 5G telecommunications, quantum computing, and biotechnology. A national security point of view on the impact of current patent eligibility laws on AI and emerging technologies should inform a national IP strategy.

2. Counter China’s narrative on winning the innovation competition: The Secretary of Commerce, in coordination with relevant departments and agencies (e.g., Department of State, USTR), should address how the United States might best counter China’s efforts to shape the narrative that it is winning the innovation competition based in part on its patent application filings and other interventions in its technology markets.¹³⁹ China has become the domestic forum with the highest number of patent application filings and China’s companies and inventors are the most prolific AI patent application filers globally.¹⁴⁰ This benchmark helps to shape the narrative that China has become the leader in innovation because intensive patenting generally correlates to economic growth, even if it does not imply causation.¹⁴¹ China also is garnering this

¹³⁶ In January 2019, the USPTO published the initial framework in a Revised Guidance and requested public comment on the Guidance. See 84 Fed. Reg. 50, *United States Patent and Trademark Office: 2019 Revised Patent Subject Matter Eligibility Guidance*, U.S. Patent and Trademark Office (Jan. 7, 2019), <https://www.federalregister.gov/documents/2019/01/07/2018-28282/2019-revised-patent-subject-matter-eligibility-guidance>. Once the USPTO received comments, it issued an Update to the Guidance. *October 2019 Update: Subject Matter Eligibility*, U.S. Patent and Trademark Office (Oct. 2019), https://www.uspto.gov/sites/default/files/documents/peg_oct_2019_update.pdf. The Revised Guidance and the Update were later incorporated into the newest edition of the USPTO’s Manual of Patent Examining Procedure when it was revised in June 2020. See *Manual of Patent Examining Procedure*, United States Patent and Trademark Office at §§ 2103–2106.07(c) (June 2020), <https://www.uspto.gov/web/offices/pac/mpep/index.html>. Since the USPTO issued the patent eligibility guidance, uncertainty in the examination process has significantly decreased for technologies affected by the *Alice* decision. Office of the Chief Economist, *Adjusting to Alice: USPTO Patent Examination Outcomes After Alice Corp. v. CLS Bank International*, United States Patent and Trademark Office at 6–7 (April 2020), https://www.uspto.gov/sites/default/files/documents/OCE-DH_AdjustingtoAlice.pdf (demonstrating with statistical significance that the Guidance decreased uncertainty as to patent eligibility determinations in the first-action stage of examination by 44% for *Alice*-affected technologies).

¹³⁷ Though the USPTO Guidance on patent eligibility applies at the USPTO, the Federal Circuit has held that it is not bound by the Guidance and, if any conflicts arise between it and case precedent from the Federal Circuit and the Supreme Court, precedent will override the Guidance. See *Cleveland Clinic Found. v. True Health Diagnostics LLC*, 760 F. App’x 1013, 1020 (Fed. Cir. 2019) (non-precedential) (“While we greatly respect the PTO’s expertise on all matters relating to patentability, including patent eligibility, we are not bound by its guidance.”); see also *In re Rudy*, 956 F.3d 1379, 1383 (Fed. Cir. 2020) (precedential) (citing *Cleveland Clinic Found.*, 760 F. App’x at 1021 (“To the extent the Office Guidance contradicts or does not fully accord with our caselaw, it is our caselaw, and the Supreme Court precedent it is based upon, that must control.”)).

¹³⁸ Michael Borella, *The Zombie Apocalypse of Patent Eligibility Reform and a Possible Escape Route*, Patent Docs (Feb. 4, 2020), https://www.patentdocs.org/2020/02/the-zombie-apocalypse-of-patent-eligibility-reform-and-a-possible-escape-route.html?utm_source=feedburner&utm_medium=feed&utm_campaign=Feed%3A+PatentDocs+%28Patent+Docs%29 (citing an interview wherein Senator Thom Tillis, Chairman of the Senate Judiciary Committee’s Subcommittee on Intellectual Property, recognized that his 2019 patent-eligibility reform proposal did not have a “path forward” to become a bill in that Congress).

¹³⁹ Solely relying on patent counting is not reflective of innovation. See Jonathan Putnam, et al., *Innovative Output in China*, at 32 (Aug. 2020) (pending revision), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3760816 [hereinafter Putnam, *Innovative Output in China*].

¹⁴⁰ Patrick Thomas & Dewey Murdick, *Patents and Artificial Intelligence: A Primer*, Center for Security and Emerging Technology at 10 (Sept. 2020), <https://cset.georgetown.edu/wp-content/uploads/CSET-Patents-and-Artificial-Intelligence.pdf> [hereinafter CSET, *A Primer*].

¹⁴¹ Jonathan M. Barnett, *Patent Tigers and Global Innovation*, CATO at 14 (Winter 2019/2020), <https://www.cato.org/sites/cato.org/files/2019-12/v42n4-2.pdf>.

reputation when it comes to emerging technologies such as AI.¹⁴² Sources claim that China is outpacing the United States in filing worldwide AI-related patent applications.¹⁴³ However, high levels of patenting output is not necessarily indicative of high levels of inventive output.¹⁴⁴ Specifically, non-market factors driven by state sponsored interferences can distort filings.¹⁴⁵ Moreover, China often files patents as a “numbers game” which can lead to misestimating its technological prowess. Similarly, China’s 5G companies declare the most patents as “standard-essential,” appearing to marry China’s concerted, top-down strategy to advance its AI and emerging technology agenda by influencing international standards setting with its goals to dominate numeric benchmarks.¹⁴⁶ The Secretary of Commerce should examine what measures need to be undertaken to counterbalance the narrative of China’s technological dominance based on selective patenting data.

3. Impact of China’s patent application filings on USPTO and U.S. inventors: The Secretary of Commerce, in coordination with the USPTO Director, should assess whether the USPTO

¹⁴² WIPO’s Patent Cooperation Treaty (PCT) procedure allows inventors to indicate an intent to file patent applications in multiple countries. However, while in the subsequent national phase applications, a third country examines the patent and makes its own determination to grant. Therefore, experts assert that national phase applications are a better indicator for monitoring high-quality patent filings than filings under the PCT system. For information on PCT and national phase process, see *PCT FAQs*, WIPO (April 2020), <https://www.wipo.int/pct/en/faqs/faqs.html>; *WIPO Technology Trends 2019: Artificial Intelligence*, WIPO at 61-63, https://www.wipo.int/edocs/pubdocs/en/wipo_pub_1055.pdf; George Leopold, *China Dominates AI Patent Filings*, EnterpriseAI (Aug. 31, 2020), <https://www.enterpriseai.com/news/2020/08/31/china-dominates-ai-patent-filings/> (“Beijing has become a fierce defender of intellectual property linked to what planners consider a strategic technology”). Although China has a high level of PCT filings, the associated national phase applications are significantly lower. See *Patent Cooperation Treaty Yearly Review 2020: The International Patent System*, WIPO at 50 and 55 (2020), https://www.wipo.int/edocs/pubdocs/en/wipo_pub_901_2020.pdf.

¹⁴³ Yuki Okoshi, *China Overtakes U.S. in AI Patent Rankings*, Nikkei Asia (Mar. 10, 2019), <https://asia.nikkei.com/Business/Business-trends/China-overtakes-US-in-AI-patent-rankings> (“Chinese companies have surged ahead of their U.S. counterparts on a Nikkei ranking of the top 50 patent filers for artificial intelligence over the past three years, expanding their presence in the world’s most prominent high-tech battleground.”); Andrew Snowdon, *UK Ranked Fourth in the World for Number of Blockchain Patents Filed but is Falling Behind for AI Patents*, UHY Hacker Young (Jan. 21, 2019), <https://www.uhy-uk.com/insights/uk-ranked-fourth-world-number-blockchain-patents-filed-falling-behind-ai-patents> (“New Artificial Intelligence technology developments dominated by Chinese companies”).

¹⁴⁴ *5G Technological Leadership*, Hudson Institute at 2 (Dec. 2020), https://s3.amazonaws.com/media.hudson.org/Hudson_5G%20Technological%20Leadership.pdf (“There are important limitations with using patent counting as a measure of innovative output, as economists and statisticians have long recognized. . . . This is why economists consider information about the number of patents to be a ‘noisy’ indicator of innovative output. . . . What matters is the quality, not the quantity of patents.”); Jonathan Putnam, et al., *Innovative Output in China*, at 32 (Aug. 2020) (pending revision), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3760816 [hereinafter Putnam, *Innovative Output in China*]; Jonathan M. Barnett, *Patent Tigers and Global Innovation*, CATO (Winter 2019/2020), <https://www.cato.org/sites/cato.org/files/2019-12/v42n4-2.pdf>.

¹⁴⁵ Michael Mangelson, et al., *Trademarks and Patents in China: The Impact of Non-Market Factors on Filing Trends and IP Systems*, U.S. Patent and Trademark Office at 1 (Jan. 2021), <https://www.uspto.gov/sites/default/files/documents/USPTO-TrademarkPatentsInChina.pdf> (discussing China’s subsidies for trademark and patent application filings); Testimony of Mark Cohen, Senior Counsel on China in the Office of Policy and International Affairs in the United States Patent and Trademark Office before House Committee on the Judiciary, *International Antitrust Enforcement: China and Beyond* (June 7, 2016), <https://www.uspto.gov/about-us/news-updates/statement-mark-cohen-house-committee-judiciary> (discussing numerous strategies used by China to increase patent filings).

¹⁴⁶ See *Meeting the China Challenge: A New American Strategy for Technology Competition*, Working Group on Science and Technology in U.S.-China Relations at 29 (Nov. 16, 2020), https://asiasociety.org/sites/default/files/inline-files/report_meeting-the-china-challenge_2020.pdf [hereinafter *Meeting the China Challenge*]; Matthew Noble, et al., *Determining Which Companies Are Leading the 5G Race*, IAM (July/August 2019), <https://www.twobirds.com/~media/pdfs/news/articles/2019/determining-which-companies-are-leading-the-5g-race.pdf?la=en&hash=8ABA5A7173EEE8FFA612E070C0EA4B4F53CC50DE>. For example, as of February 2020, Huawei and ZTE filed the most number of “standard essential” patents (SEP)s for 5G technologies, but assessments of these filings are critical of the quality of these patents. Jed John Ikoba, *Huawei Has Filed the Most 5G Patents Globally as of February 2020 - A Report*, Gizmochina (June 2, 2020), <https://www.gizmochina.com/2020/06/02/huawei-has-the-most-5g-standard-essential-patents-globally/>.

requires additional resources, both human and technical, to ensure high quality patent examination and recommend policies to address any concerns. In doing so, the Secretary of Commerce should assess the impacts of increased filings from China and AI generated prior art (the term in patent law for the worldwide scientific and technical knowledge by which an invention is evaluated to determine if it is new). The large body of often low quality prior art created by China's high-volume patenting has the potential to adversely impact global patent examination systems, including those of the USPTO.¹⁴⁷ At the same time, U.S. inventors may face hurdles in patenting around massive amounts of low quality Chinese prior art.¹⁴⁸ The USPTO has also noted that stakeholders have raised the issues of whether AI may generate a proliferation of prior art making it difficult to find relevant prior art for examination.¹⁴⁹

4. Impediments to AI public-private partnerships and international collaboration: The Secretary of Commerce should assess any impediments to the IP contractual ecosystem to strengthen AI partnerships among national security departments and agencies, industry, and international collaboration. This should include assessing and addressing ambiguities in the Federal Acquisition Regulation and the Defense Federal Acquisition Regulation Supplement relevant to AI and data. AI development presents unique IP contractual issues. For example, industry AI developers will likely need access to relevant United States Government training data to develop AI-enabled government solutions or applications. If the solution or application is dual use, the private entity may want to provide a license for the United States Government agency to access the AI application, but retain the IP in the AI model to license to others. But there are unanswered questions as to whether the United States Government agency has any IP rights or ownership in the model that was trained on its data.¹⁵⁰ The United States Government agency may also want to retain IP rights in order to avoid “vendor lock.”¹⁵¹ These outstanding questions about IP rights and ownership issues could also arise in international AI system R&D collaboration, where impediments can be amplified by conflicting national laws on IP and/or data protections.

¹⁴⁷ The potential impact of Chinese patent prior art that must be examined at the USPTO can be likened to what is happening to the USPTO trademark application process. An influx of fraudulent trademark applications from China, supported by monetary incentives from the Chinese government, is likely damaging the integrity of the U.S. trademark registration process, including by imposing unpredictability in examination process schedules. *Hearing on Fraudulent Trademarks: How They Undermine the Trademark System and Harm American Consumers and Businesses*, U.S. Senate Committee on the Judiciary, Subcommittee on Intellectual Property (Dec. 3, 2019), <https://www.judiciary.senate.gov/meetings/fraudulent-trademarks-how-they-undermine-the-trademark-system-and-harm-american-consumers-and-businesses>; Barton Beebe & Jeanne C. Fromer, *Are We Running Out of Trademarks? An Empirical Study of Trademark Depletion and Congestion*, *Harvard L. Rev.* (Feb. 9, 2018), <https://harvardlawreview.org/2018/02/are-we-running-out-of-trademarks/>; Josh Gerben, *Massive Wave of Fraudulent US Trademark Filings Likely Caused by the Chinese Government Payments*, Gerben (last accessed Jan. 3, 2021), <https://www.gerbenlaw.com/blog/chinese-business-subsidies-linked-to-fraudulent-trademark-filings/>.

¹⁴⁸ Jeanne Suchodolski, et al., *Innovation Warfare*, *North Carolina Journal of Law & Tech* at 201 (Dec. 2020), <https://ncjolt.org/articles/volume-22/volume-22-issue-2/innovation-warfare/> [hereinafter *Innovation Warfare*].

¹⁴⁹ *Public Views on Artificial Intelligence and Intellectual Property Policy*, U.S. Patent and Trade Office at iii (Oct. 2020), https://www.uspto.gov/sites/default/files/documents/USPTO_AI-Report_2020-10-07.pdf [hereinafter USPTO AI IP policy report].

¹⁵⁰ Richard Vray & Jane Mutimear, *Artificial Intelligence - Navigating the IP Challenges*, *Mobile World Live* (Feb. 16, 2019), <https://www.mobileworldlive.com/intellectual-property-news/artificial-intelligence-navigating-the-ip-challenges>.

¹⁵¹ David Deptula, *The Growing Importance of Data Rights in Defense Acquisition*, *Forbes* (Oct. 16, 2018), <https://www.forbes.com/sites/davedeptula/2018/10/16/the-growing-importance-of-data-rights-in-defense-acquisition/?sh=165063242a04>.

5. IP protection for data: The Secretary of Commerce should assess whether there is a need for *sui generis* protection or additional IP-type of protections for data, and propose policies and/or legislation if protection is deemed necessary. Data is critical to AI and machine learning, but gaps may exist in current protection regimes afforded by patent or copyright. Inadequate protections for data may disincentivize the necessary investments in developing these critical datasets as well as any public disclosure or sharing agreements.¹⁵² While protections for data might be a future need, the U.S. should be proactive in assessing and addressing the necessity of such protections. The Secretary of Commerce also should explore ways to protect and incentivize creation of datasets while allowing the data to be shared at some point, particularly with smaller entities that might not otherwise be able to enter the market.¹⁵³ An analysis of the strengths and weaknesses of the European *sui generis* database protections should inform this assessment.¹⁵⁴

6. Combat IP theft: The Secretary of Commerce, in coordination with relevant departments and agencies (e.g., United States Trade Representative, Intellectual Property Enforcement Coordinator, the National Science Foundation, the Office of Science and Technology Policy,¹⁵⁵ as well as the Departments of Homeland Security,¹⁵⁶ Justice,¹⁵⁷ and State) should assess and identify additional efforts the Executive Branch should undertake to counter IP theft threats, including actions in collaboration with allies and partners.¹⁵⁸ In particular, the Secretary of Commerce should clearly articulate that the U.S. counter-IP theft strategy will contain both criminal and civil economic dimensions. The Department of Commerce should utilize all available tools for establishing a deterrence regime to punish firms guilty of stealing U.S. IP and deter future IP theft to level the playing field for U.S. and allied firms. These tools should include placing offending companies on the Bureau of Industry & Security entity list,¹⁵⁹ blocking visas of key employees, or levying tariffs against products derived from stolen IP. Solutions that should be explored include training for allies and partners to stop counterfeits at borders, and efforts to increase individuals' respect for IP and recognition of and ways to avoid counterfeits. In addition, the Secretary should assess methods and means for strengthening and updating existing mechanisms available to American victims of trade secret theft, including reintroducing

¹⁵² In the USPTO report surveying stakeholders for perspectives on IP policy for AI, “commenters were nearly equally divided between the view that new intellectual property rights were necessary to address AI inventions and the belief that the current U.S. IP framework was adequate to address AI inventions. Generally, however, commenters who did not see the need for new forms of IP rights suggested that developments in AI technology should be monitored to ensure needs were keeping pace with AI technology developments. The majority of opinions requesting new IP rights focused on the need to protect the data associated with AI, particularly ML.” USPTO AI IP policy report at 15; *id.* at 38 (“[a] smaller number of commenters did suggest a reconsideration of whether additional protections of datasets and databases could be useful to spur investment in high-quality data of vetted/assured provenance.”).

¹⁵³ See USPTO AI IP policy report at 15.

¹⁵⁴ *Protection of Databases*, European Commission (June 1, 2018), <https://ec.europa.eu/digital-single-market/en/protection-databases>; USPTO AI IP policy report at 38.

¹⁵⁵ This includes the Joint Committee on the Research Environment (JCOPE).

¹⁵⁶ This includes the U.S. Customs and Border Protection.

¹⁵⁷ This includes the Computer Crime and Intellectual Property Section (CCIPS).

¹⁵⁸ See Meeting the China Challenge at 16 (“In concert with allies and like-minded countries, the U.S. should investigate, punish, and condemn such acts and identify ways to induce changes in China’s maneuvers through counter-espionage, law enforcement, diplomatic pressure, and professional training in scientific integrity.”).

¹⁵⁹ Press Release, The U.S. Department of Commerce, *Statement from Secretary Ross on The Department's 77 Additions to the Entity List for Human Rights Abuses, Militarization of the South China Sea and U.S. Trade Secret Theft* (Dec. 18, 2020), <https://www.commerce.gov/news/press-releases/2020/12/statement-secretary-ross-departments-77-additions-entity-list-human>.

legislation to strengthen the Economic Espionage Act by, for example, increasing damages available to trade theft victims and extending the statute of limitations.¹⁶⁰

7. Inventorship by AI: The Secretary of Commerce should assess the need for policy changes for issues raised by AI generated inventions and creations, particularly as technologies evolve. The USPTO has determined that under current legal doctrine, an inventor must be a natural person and denied a patent application naming a machine as the inventor.¹⁶¹ The U.S. is not alone in this position.¹⁶² The USPTO also issued extensive requests for public comments on a variety of AI IP policy issues, including AI’s impact on inventorship and ownership, as well as impacts on non-patent IP protections, such as copyright. As a result, the USPTO issued a comprehensive report of public views on AI and IP policy. The majority of commenters agreed that given current AI capabilities are limited to “narrow AI” (AI systems that are trained and perform individual tasks in well-defined domains) and AGI is not yet a reality, current AI could neither invent nor author without human intervention.¹⁶³ The Secretary of Commerce should consult with allies and partners to ensure continued harmonization around the various IP issues raised by AI generated inventions and creations, and gain an understanding of China’s strategies for addressing these issues, particularly as AI technologies move past narrow AI.

8. Global IP alignment: The Secretary of Commerce, in coordination with relevant departments and agencies (e.g., USPTO, IPEC, USTR, Department of Defense, Department of State), should work with partners and allies to develop global disincentives for IP theft, and alleviate any inconsistencies in patent regimes that make it overly difficult for companies to protect their patents in multinational markets. In doing so, the Secretaries should leverage the Commission’s recommendation that the United States and allies—through the Emerging Technology Coalition—explore coordinated approaches to IP (as part of the NSCAI proposed critical area #4: Promoting and Protecting Innovation¹⁶⁴), including a mutual agenda within the WIPO’s Conversation on AI and IP, and forums with broader mandates. The Secretaries also should assess whether current forums for dialogues on global IP alignment are sufficient or whether new

¹⁶⁰ Charles Barquist & Maren Laurence, *How a Biden Administration Would Shape IP Policy*, Law 360 (Oct. 19, 2020), <https://www.law360.com/articles/1319716/how-a-biden-administration-would-shape-ip-policy>; Sean Lyngaas, *As China Tensions Mount, U.S. Officials Outline Efforts to Combat Economic Espionage*, CyberScoop (Dec. 12, 2018), <https://www.cyberscoop.com/china-tensions-mount-u-s-officials-outline-efforts-combat-economic-espionage/>; see also 18 U.S.C. § 1831 (regarding economic espionage); 18 U.S.C. § 1832 (regarding theft of trade secrets).

¹⁶¹ Robert Bahr, *Decision on Petition: Application No.: 16/524,350*, U.S. Patent and Trademark Office (2020), https://www.uspto.gov/sites/default/files/documents/16524350_22apr2020.pdf.

¹⁶² Consistent with U.S. policy that an inventor must be a human “natural person,” in January 2020, the European Patent Office (EPO) and the UK Intellectual Property Office (UKIPO) rejected two patent applications that identified the AI machine as the inventor. The EPO and UKIPO found that the applications met the requirements for patentability, but rejected the applications because the inventor was not a “human being.” See Emma Woollacott, *European Patent Office Rejects Worlds’ First AI Inventor*, Forbes (Jan. 3, 2020), <https://www.forbes.com/sites/emmawoollacott/2020/01/03/european-patent-office-rejects-worlds-first-ai-inventor/?sh=2915e17d5cd0>; Angela Chen, *Can an AI be an Inventor? Not Yet.*, MIT Technology Review (Jan. 8, 2020), <https://www.technologyreview.com/2020/01/08/102298/ai-inventor-patent-dabus-intellectual-property-uk-european-patent-office-law/>; *EPO Provides Reasoning for Rejecting Patent Applications Citing AI as Inventor*, IPWatchdog (Jan. 28, 2020), <https://www.ipwatchdog.com/2020/01/28/epo-provides-reasoning-rejecting-patent-applications-citing-ai-inventor/id=118280/>.

¹⁶³ USPTO AI IP policy report at ii-iii.

¹⁶⁴ See the Blueprint for Action for Chapter 15 and its associated Annex for more details on the proposed critical areas for international alignment for the Emerging Technology Coalition. Critical area #4, as detailed in the Blueprint for Action and Annex, is: Promoting and protecting innovation, including through intellectual property alignment. Recognizing the importance of IP to promote and protect innovation, the critical area proposes coordination on assistance to nations in developing strong and aligned IP regimes, coordinated efforts to stop IP theft and counter cyber espionage, and aligning on a mutual agenda within IP-related multilateral forums.

forums or venues are necessitated, particularly given any changes to domestic IP policies or regimes identified during the review of the other IP considerations. For example, if the United States determines new protections or policies are needed for data, the U.S. may need to work with key allies and partners—bilaterally and multilaterally—to ensure global harmonization.

9. Democratize innovation and IP ecosystems: The Secretary of Commerce should assess whether additional Executive Branch efforts are necessary to expand the innovation base and democratize access to and create more jobs in the innovation and IP ecosystem.¹⁶⁵ The USPTO, in collaboration with the Secretary of Commerce, has undertaken initiatives to expand the U.S. innovation base by creating the National Council for Expanding American Innovation (NCEAI) to develop a comprehensive national strategy to increase equity and fuel the U.S. innovation ecosystem by encouraging, empowering, and supporting all future innovators.¹⁶⁶ The Secretary of Commerce should ensure that the USPTO has the full support of the Executive Branch in these initiatives. As part of the NCEAI initiative, the Secretary of Commerce also should focus on assessing and identifying potential actions and tools that can fast track processes and streamline guidance for startups seeking IP protections, and ensuring resources for assisting small and medium sized entities. Such a focus is particularly important when comparing the impact of litigation costs and potentially overly burdensome processes in the U.S. relative to other countries on U.S. inventors’ decisions to pursue IP protections in the United States.¹⁶⁷

10. “Standard essential” patents process:¹⁶⁸ The Secretary of Commerce, in coordination with the USPTO, NIST, and the Department of State should assess policies by which the U.S. can serve a leadership role in and ensure U.S. firms are able to fully participate in the processes by which “standard essential” patents are claimed and asserted.¹⁶⁹ This would help ensure the continuing legitimacy of the standard-setting process, a privately developed method for

¹⁶⁵ “To maintain our technological leadership, the United States must seek to broaden our intellectual property ecosystem demographically, geographically, and economically.” *Expanding Innovation*, USPTO (last accessed Jan. 3, 2021), <https://www.uspto.gov/initiatives/expanding-innovation> (quoting USPTO Director Andrei Iancu).

¹⁶⁶ *Remarks by Commerce Secretary Wilbur L. Ross at the First Meeting of the National Council for Expanding American Innovation*, U.S. Department of Commerce (Sept. 14, 2020), <https://www.commerce.gov/news/speeches/2020/09/remarks-commerce-secretary-wilbur-l-ross-first-meeting-national-council>; *Support the National Council for Expanding American Innovation*, USPTO (last accessed Jan. 3, 2021), <https://www.uspto.gov/initiatives/expanding-innovation/national-council-expanding-innovation/support-national-council>.

¹⁶⁷ “A significant proportion of lawyers are advising clients with products in the global market to patent in China, Germany, and even the UK instead of the US. The US is losing the fight to be the major center of patents, investment, and tech because it is easier and less expensive for companies to file and ensure their patents are enforced in other countries than in the US.” NSCAI staff engagement with Robert Taylor, owner of RPT Legal Strategies PC (Oct. 8, 2020).

¹⁶⁸ Through the standards-setting process, standards-setting bodies (e.g., ISO, IEC, IEEE, ITU, and others) often require that patent owners self-identify patents that *may be* deemed essential in a future standard. This requirement aims to ensure transparency and often requires commitments by these patent owners to license their patents fairly, reasonably, and non-discriminatorily. However, these standards-setting bodies do not assess whether a patent is essential or not, leaving these determinations to private companies negotiating licenses or, if there is a dispute, to courts. See *IEEE SA Standards Board Bylaws*, IEEE, <https://standards.ieee.org/about/policies/bylaws/sect6-7.html#loa>.

¹⁶⁹ See Chapter 15 of this report and its associated Blueprint for Action for the coordinated U.S. national plan to support international technology efforts and its first component on shaping international technical standards as well as Chapter 15’s Annex: Emerging Technology Coalition for more details on proposed international technical standards-setting recommendations for NIST, the Department of State, and other critical Departments and Agencies. NSCAI recommends that the U.S. government provide greater attention to and resourcing for international technical standardization efforts; increase interagency coordination on AI-related standards-setting; strengthen partnerships and collaboration with the private sector, particularly through a federal advisory committee and a grant program to enable small-and medium-sized U.S. AI companies to participate in international standardization efforts; and increase international alignment with key partners and allies. See also Meeting the China Challenge, at 27.

efficiently coordinating development and deployment of new technologies in the marketplace, and deflect Beijing’s attempt to dominate or manipulate these processes through its own coordination of firms from China. Chinese Communist Party leadership has articulated a linkage between patent leadership in emerging technologies like AI and the standards-setting processes for these same technologies.¹⁷⁰ Current trends confirm China’s intention to use both patents and standards to lead in technological innovation.¹⁷¹ Additional mechanisms may be necessary to protect the integrity of international standards-setting as well as to protect and promote U.S. innovation, such as identifying efforts by foreign governments to influence, directly or indirectly, standard-setting organizations. This would also include identifying foreign governments subsidizing or otherwise incentivizing the over-declaration of patents as “standard essential”¹⁷² or creating barriers to U.S. participation in foreign standard-setting bodies. The Secretary of Commerce should also explore how the U.S. government might support smaller U.S. companies and inventors fully participating in the standard-setting process and encourage the observation of licensing or legal disputes in foreign jurisdictions by U.S. government officials from U.S. Embassies and Missions. Relatedly, the Secretary of Commerce, in coordination with the Director of the USPTO, should assess foreign court rulings on licensing that may impact U.S. national sovereignty to determine a coherent U.S. position or response.¹⁷³

¹⁷⁰ Dai Hong, the director of China’s National Standardization Committee’s Industrial Standards Department stated in January 2018, as the research for China Standards 2035 was launched: “In today’s world, industry, technology and innovation are developing rapidly. The new generation of information technology industry represented by artificial intelligence, big data, cloud computing, etc. is emergent. International technology research and development and patent distribution have not yet been completed. Global technical standards are still being formed. This offers the opportunity to realize the transcendence of China’s industry and standards.” See translated quote from January 20, 2018 on the China News Network in Emily de la Bruyere & Nathan Picarsic, *China Standards 2035: Beijing’s Platform Geopolitics and ‘Standardization Work in 2020’*, Horizon Advisory at 6 (Apr. 2020), <https://www.horizonadvisory.org/china-standards-2035-first-report>. Additionally, the Guangdong High People’s Court published an October 2013 opinion piece that argued for ““Chinese enterprises to make a revival, there is only one road to take: strengthen our capacity for innovation, and only by gaining control over SEPs can Chinese companies avoid being ‘led by the nose’””. It cited Chief Judge Qiu Yongqing, who ruled against the U.S. InterDigital in its lawsuit against Huawei, and argued that “Chinese enterprises should bravely employ anti-monopoly lawsuits to break technology barriers and win space for development.” See David Cohen & Douglas Clark, *China’s Anti-monopoly Law as a Weapon Against Foreigners*, IAM-media (Nov./Dec. 2018), https://kidonip.com/wp-content/uploads/2018/11/IAM92_China-anti-monopoly_section_0.pdf.

¹⁷¹ Innovation Warfare, at 201, n.130 (China’s firms recognize the strategic importance of standard setting activities and that participation in those forums provides the legal means to both access and influence developing technologies). “In recent years the PRC government decided that promoting Chinese standards in global standards bodies via the work of Huawei and other Chinese companies is key to realizing techno-nationalist goals for technological ascension. Viewed in this context, Huawei is in the vanguard of the Chinese effort to establish dominance in both the number and significance of Chinese patents that are deemed “standard essential” to 5G standards...it is in the U.S. interest to deflect Beijing’s attempt to dominate the standard-setting process.” See Meeting the China Challenge at 29. See also Matthew Noble, et al., *Determining Which Companies Are Leading the 5G Race*, IAM (July/August 2019), <https://www.twobirds.com/~media/pdfs/news/articles/2019/determining-which-companies-are-leading-the-5g-race.pdf>.

¹⁷² Over declaration is already present in 5G. See Matthew Noble, et al., *Determining Which Companies Are Leading the 5G Race*, IAM (July/August 2019), <https://www.twobirds.com/~media/pdfs/news/articles/2019/determining-which-companies-are-leading-the-5g-race.pdf>.

¹⁷³ Countries are increasingly seeking to attract inventors by setting favorable global royalty rates (see the UK’s decision in *Unwired Planet v. Huawei*) or by controlling the jurisdiction in which companies may file for injunctive relief or pursue litigation. For example, licensing disputes have recently led to additional satellite litigation involving broader issues of international law and comity between China and other legal jurisdictions. Experts predict disputes to increase and warn of cycle of anti-suit, “anti-anti-suit,” and “anti-anti-anti-suit” injunctions. See Mark Cohen, *Wuhan and Anti-Suit Injunction*, China IPR Blog (Dec. 28, 2020), <https://chinaipr.com/2020/12/28/wuhan-and-anti-suit-injunctions/>; Dani Kass, *FRAND Rate ‘Nightmare’ Raises Call For International Tribunal*, Law360 (Jan. 14, 2021), <https://www.law360.com/articles/1343824/frand-rate-nightmare-raises-call-for-international-tribuna/>; Michael Renaud et al, *Key Considerations for Global SEP Litigation - Part 1*, The National Law Review (Oct. 30, 2019), <https://www.natlawreview.com/article/key-considerations-global-sep-litigation-part-1>; Michael Renaud et al, *Key Considerations for Global SEP Litigation - Part 2*, The National Law Review (Nov. 5, 2019), <https://www.natlawreview.com/article/key-considerations-global-sep-litigation-part-2>; Zhao Qishan & Lu Zhe, *Statistics of*

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**Chapter 13: Microelectronics
Blueprint for Action**

Regaining microelectronics leadership requires meeting an explicit objective: Stay at least two generations ahead of China in state-of-the-art microelectronics and maintain multiple sources of cutting-edge microelectronics fabrication in the United States. To do this, the Executive Branch must prepare and implement a national microelectronics strategy while Congress simultaneously institutes new tax credits, subsidizes the construction of semiconductor manufacturing facilities, and grows federal microelectronics R&D and infrastructure funding. Achieving this goal will require roughly \$30 billion in additional federal funding but these funds should attract more than five times as much private sector investment. Additional federal funding on this scale will likely boost economic activity domestically and could add more than a hundred billion dollars to U.S. gross domestic product (GDP).¹⁷⁴ Inside the U.S. government, agencies must also expand access to trustworthy, high-performance microelectronic components by shifting from serial to concurrent development of hardware and softwares to catch up to the commercial sector and make use of new microelectronics produced in the United States.

Five-Year Microelectronics Funding

Category	Amount
Federal Grants for Microelectronics Manufacturing*	\$3 billion per project (\$15 billion total)
Microelectronics R&D	\$12 billion
Microelectronics Infrastructure	\$7 billion
DoD Trusted & Assured Microelectronics	\$0.5 billion
Total	\$35 billion

*Excludes tax expenditures from proposed refundable investment tax credit

Recommendation: Issue an Executive Order on Microelectronics Strategy and Leadership

The United States needs a national microelectronics strategy to coordinate semiconductor policy, funding, and incentives within the Executive Branch and externally with industry and academia.

Actions for the President:

- **Issue an Executive Order on Microelectronics National Strategy and Leadership.**
 - The first step in rebuilding microelectronics leadership is clearly stating that it is a Presidential priority to stay at least two generations ahead and maintain multiple sources of cutting-edge microelectronics fabrication in the United States. The Administration should also highlight the importance of the legislatively required National Microelectronics Strategy and create a durable structure for its development, implementation, and revision by issuing an Executive Order requiring the NDAA-mandated Subcommittee on Microelectronics Leadership to

¹⁷⁴ *Sparkling Innovation: How Federal Investment in Semiconductor R&D Spurs U.S. Economic Growth and Job Creation*, Semiconductor Industry Association at 2 (June 2020) https://www.semiconductors.org/wp-content/uploads/2020/06/SIA_Sparking-Innovation2020.pdf; *Semiconductor Incentives*, Semiconductor Industry Association at 2 (Oct. 9, 2020) <https://www.semiconductors.org/wp-content/uploads/2020/10/Incentives-Infographic-2020.pdf>.

lead a process to develop a clear federal strategy for microelectronics leadership. Draft text to inform the development of an Executive Order for this purpose is included as an annex to this Blueprint for Action.

Recommendation: Revitalize Domestic Microelectronics Fabrication

Existing U.S. incentives offset the cost of semiconductor foundry construction attributable to capital expenses, operating expenses, and taxes by 10 to 15 percent.¹⁷⁵ Yet additional tax credits and subsidies are needed to make the United States a globally competitive market for semiconductor manufacturing, especially leading-edge logic facilities. Other leading semiconductor manufacturing nations such as South Korea, Taiwan, and Singapore offer 25 to 30 percent cost reduction, roughly double what the United States currently offers.¹⁷⁶ This gap in incentives is one driving factor behind the lack of an advanced logic merchant foundry in the United States. Closing the gap will encourage U.S. firms to construct facilities domestically while also attracting foreign firms. In fact, a program of the size described here is projected to attract roughly 14 new fabs in the United States over 10 years.¹⁷⁷ Additionally, increasing demand in the United States for high-end semiconductor manufacturing equipment (SME) will create new business opportunities for SME manufacturers from allied countries, particularly Japan and the Netherlands, which could increase their governments' willingness to align their export control policies with U.S. policies prohibiting the export of such equipment to China.¹⁷⁸ A refundable investment tax credit should be instituted in combination with funding for federal grants for the expansion, construction, and modernization of semiconductor manufacturing equipment authorized in the NDAA.¹⁷⁹

Action for Congress:

- **Create a 40 percent refundable investment tax credit for domestic semiconductor manufacturing.**
 - Congress should pass legislation establishing a 40 percent refundable federal investment tax credit for semiconductor manufacturing facilities and equipment required to produce state-of-the-art logic chips. This incentive would reduce a semiconductor firm's tax bill by 40 percent on semiconductor manufacturing equipment and facilities through 2024, followed by reduced tax credit rates of 30 percent and 20 percent, respectively, through 2025 and 2026. Although introduced as part of the CHIPS for America Act, Congress has not yet passed legislation establishing this credit.¹⁸⁰

¹⁷⁵ Antonio Varas, et al., *Government Incentives and US Competitiveness in Semiconductor Manufacturing*, Boston Consulting Group and Semiconductor Industry Association at 19 (Sept. 2020), <https://web-assets.bcg.com/27/cf/9fa28eeb43649ef8674fe764726d/bcg-government-incentives-and-us-competitiveness-in-semiconductor-manufacturing-sep-2020.pdf>.

¹⁷⁶ Id.

¹⁷⁷ Id.

¹⁷⁸ See Chapter 14 of this report for additional details regarding export controls on SME.

¹⁷⁹ Total matching funding will vary based on the number of projects approved but should have a ceiling of at least \$10-\$15 billion.

¹⁸⁰ S. 3933, 116th Cong. (2020); H.R. 7178, 116th Cong. (2020).

- **Appropriate funding authorized in the FY 2021 NDAA for domestic semiconductor manufacturing incentives, including matching funds for semiconductor fabrication facilities**
 - The FY 2021 NDAA authorizes the Secretary of Commerce to establish a Federal financial assistance program to incentivize investment in facilities and equipment in the United States for semiconductor fabrication, assembly, testing, advanced packaging, or research and development. Under the program, the Secretary may authorize up to \$3 billion per project to finance the construction, expansion, or modernization of facilities and equipment for semiconductor manufacturing. Larger subsidies are also permitted if the project significantly increases the proportion of semiconductors relevant for national security and economic competitiveness that can be met through reliable domestic production. However, this judgement requires the concurrence of the Secretary of Defense and Director of National Intelligence.
 - Although authorized in the FY 2021 NDAA, funds have not yet been appropriated toward this program. Congress should appropriate at least \$15 billion to subsidize several facilities in the United States to meet the end-goal of multiple state-of-the-art sources for domestic fabrication.

Recommendation: Double Down on Funding for Research and Infrastructure to Lead the Next Generation of Microelectronics

Four research arms of the U.S. government focused on medium- and long-term microelectronics breakthroughs through engagement with academia and industry are the Department of Energy (DOE), the Defense Advanced Research Projects Agency (DARPA), the National Science Foundation (NSF), and the Department of Commerce. Their suite of existing programs, such as DARPA's Electronics Resurgence Initiative (ERI), are targeting the right research areas but must be expanded by an order of magnitude to achieve the necessary breakthroughs to maintain U.S. competitiveness. Additional funding should support not only research projects but also the capital-intensive infrastructure for microelectronics development, including the National Semiconductor Technology Center and advanced packaging prototyping programs authorized in the FY 2021 NDAA. In line with the existing focus areas of these programs and the Commission's prior recommendations, funding should pursue breakthroughs in promising technologies such as 3D chip stacking, photonics, carbon nanotubes, gallium nitride transistors, domain-specific hardware architectures, electronic design automation, and cryogenic computing. In particular, funding should prioritize the development of manufacturing equipment and tools to reach 3 nm and beyond at production scale. However, this funding should not solely be directed to classical computing technologies. The U.S. government should also support efforts to research and develop hybrid quantum-classical techniques that leverage noisy intermediate-scale quantum computers. The Commission offers detailed recommendations on this subject in Chapter 16.

Action for Congress:

- **Appropriate \$1.1 billion for semiconductor R&D in FY 2022 and continue increasing funding over the next five years for a total of \$12 billion**
 - Congress should appropriate an additional \$1.1 billion in FY 2022. Consistent with the amounts in the CHIPS for America Act, this funding should include \$400 million for DARPA ERI, \$300 million for NSF semiconductor research, and \$400 million for DOE semiconductor research. These funding levels should be grown over the following five years to roughly \$7 billion per year and \$12 billion total. Recognizing it will take time to build capacity among agencies to administer programs at the necessary scale, these amounts should start at funding levels that can be absorbed by agencies and ramped up over time.

- **Appropriate \$1 billion in FY 2022 and \$5 billion total over five years for the Advanced Packaging National Manufacturing Program.**
 - Novel packaging techniques such as heterogeneous integration and 3D stacking -- combined with domain-specific architectures -- will be critical to the development of AI as traditional architectures of silicon-based chipsets encounter diminishing marginal performance improvements. Congress should also appropriate \$1 billion in initial FY 2022 funding to establish the Advanced Packaging National Manufacturing Program led by the National Institute of Standards and Technology (NIST), as authorized by the FY 2021 NDAA.¹⁸¹ This funding should be continued through FY 2027 for a total of \$5 billion.

- **Appropriate \$100 million in FY 2022 and \$2 billion over five years to establish the National Semiconductor Technology Center**
 - A National Semiconductor Technology Center would serve as a microelectronics research hub while also conducting prototyping of advanced semiconductors in partnership with the private sector. Early stage semiconductor startups currently face difficulties scaling due to the high costs of microelectronics design and fabrication. The incubator component of the center could provide resources to promising, early-stage microelectronics startups, while also giving them access to fabrication facilities, design tools, and shared intellectual property to assist with early-stage development costs. It could also partner with the International Development Finance Corporation (DFC) to provide loan guarantees to microelectronics firms if DFC's authorities are expanded and extended to rebuild domestic supply chains for a broader range of strategic emerging technologies.¹⁸² This laboratory could grow into a center of expertise in high-performing, trusted

¹⁸¹ Pub. L. 116-283, sec. 9906, William M. (Mac) Thornberry National Defense Authorization Act for Fiscal Year 2021, 134 Stat. 3388 (2021).

¹⁸² See the Chapter 16 Blueprint for Action for further details on extending and expanding DFC's loan guarantee program through executive action.

microelectronics, ensuring continued U.S. leadership in this field over the ensuing years.

Recommendation: Continue DoD's Trusted Microelectronics Program and Adopt Agile Hardware Development

Semiconductor manufacturing has moved offshore, expanding threat vectors to hardware security, and leaving the U.S. government unable to trust sensitive electronic components it needs for defense systems. And while the U.S. government is now recognizing it must take steps to adopt modern software practices, there has been less attention on incorporating hardware into the agile development process. Both issues require attention from DoD and other government agencies. The U.S. government needs to inject security and agility into its microelectronics acquisition and development process to leverage the best technology possible for defense systems.

Actions for Department of Defense:

- **Continue growing the Trusted & Assured Microelectronics Program, to include AI-enabling hardware.**
 - DoD's Trusted and Assured Microelectronics research, development, test, and evaluation (RDT&E) funding has grown to over \$500 million annually for advanced component development and prototyping and system development and demonstration.¹⁸³ These programs improve access to advanced packaging and testing; support the development of quantifiable assurance and secure design; develop foundry access standards; expand access to non-complementary metal oxide semiconductor (CMOS) state-of-the-art microelectronics; support disruptive research and development; and promote education and workforce development. These are foundational microelectronics capabilities that will also enable the development and application of AI/ML capabilities across national security mission areas. In FY 2021 and beyond, USD R&E should expand the program to focus on developing AI-enabling capabilities and apply \$50 million of funding toward developing AI-multi-chip packages.
- **Shift to a more agile approach to hardware development and procurement.**
 - Just as agile development has transformed software, there is an opportunity to bring agile hardware design practices to speed development cycles, lower costs, and increase performance. Rather than designing through a serial process, the commercial sector has developed best practices to integrate hardware and software development processes concurrently. While DoD has made strides in agile software development, it remains behind the commercial sector in applying these lessons to hardware. Broader adoption of hardware emulation and moving to a common and secure design environment for the chip, package, and board would

¹⁸³ Pub. L. 116-260, Division C, Department of Defense Appropriations Act (2021), <https://docs.house.gov/billsthisweek/20201221/BILLS-116RCP68-JES-DIVISION-C.pdf>.

also accelerate system development and improve security. This requires the combined efforts of USD R&E and USD A&S to continue improving software acquisition and development practices to incorporate hardware.

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Chapter 13 Annex: Executive Order on Microelectronic Strategy

By the authority vested in me as President by the Constitution and the laws of the United States of America, including section 9906 of the National Defense Authorization Act (NDAA) for Fiscal Year 2021 (Public Law 116-283), it is hereby ordered as follows:

Section 1. Findings. The United States relies heavily on imports of certain microelectronics that are vital to the Nation's security and economic prosperity. This dependency on semiconductor imports creates strategic economic and military vulnerabilities to supply chain disruptions for electronics, including adverse foreign government actions and natural disasters. Despite tremendous expertise in microelectronics research, development, and innovation across the country, the United States is limited by a lack of domestically located semiconductor fabrication facilities, especially for state-of-the-art semiconductors. This limitation compounds the risk that the United States may be outpaced in microelectronics design and fabrication. Focusing the efforts of the United States Government, industry, and academia to develop domestic microelectronics fabrication facilities will reduce the Nation's dependence on imports, preserve U.S. leadership in technological innovation, support job creation, strengthen national security and balance of trade, and enhance the technological superiority and readiness of the Armed Forces, which are important consumers of advanced microelectronics.

Sec 2. Policy. To maintain the Nation's security and economic prosperity, it shall be the policy of the United States to stay at least two generations ahead of potential adversaries in state-of-the-art microelectronics and maintain multiple sources of cutting-edge microelectronics fabrication in the United States.

Sec. 3. Establishment of Subcommittee on Microelectronics Leadership. (a) There is hereby established in the National Science and Technology Council a subcommittee on matters relating to leadership and competitiveness of the United States in microelectronics technology and innovation to be named the Subcommittee on Microelectronics Leadership (Subcommittee).

(b) The Subcommittee shall be composed of the following members:

- (i) The Secretary of Commerce, who shall be Chair of the Subcommittee.
- (ii) The Secretary of State;
- (iii) The Secretary of Defense;
- (iv) The Secretary of Energy;
- (v) The Secretary of Homeland Security;
- (vi) The Director of the Office of Management and Budget;
- (vii) The United States Trade Representative;

- (viii) The Director of National Intelligence;
 - (ix) The Director of the National Science Foundation;
 - (x) The Assistant to the President for Science and Technology;
 - (xi) The Assistant to the President for Technology Competitiveness;
 - (xii) The Assistant to the President for National Security Affairs;
 - (xiii) The Assistant to the President for Economic Policy;
 - (xiv) The Assistant to the President for Domestic Policy; and
 - (xv) The heads of other executive departments and agencies and other senior officials within the Executive Office of the President, as determined by the Chair.
- (c) Sunset. The Subcommittee shall terminate on January 1, 2031.

Sec. 4. Functions of the Subcommittee on Microelectronics Leadership. Consistent with applicable law, the Subcommittee shall:

- (a) advise the President on matters involving policy affecting microelectronics;
- (b) develop, within 270 days of the date of this order, and no less than once every five years thereafter, a National Strategy on Microelectronics Research, Development, Manufacturing, and Supply Chain Security (Strategy), which shall address the following elements:
 - (i) methods to accelerate the domestic development and production of microelectronics and strengthen the domestic microelectronics workforce;
 - (ii) methods to ensure that the United States is a global leader in the field of microelectronics research and development;
 - (iii) activities that may be carried out to strengthen engagement and outreach between Federal agencies and industry, academia, and international partners of the United States on issues relating to microelectronics;
 - (iv) priorities for research and development to accelerate the advancement and adoption of innovative microelectronics and new uses of microelectronics and components;
 - (v) the role of diplomacy and trade in maintaining the position of the United States as a global leader in the field of microelectronics;

(vi) the potential role of a Federal laboratory, center, or incubator exclusively focused on the research and development of microelectronics, as described in section 231(b)(15) of the NDAA for Fiscal Year 2017 (as added by section 276 of the NDAA for Fiscal Year 2021) in carrying out the Strategy; and

(vii) such other activities as the Subcommittee determines may be appropriate to overcome future challenges to the innovation, competitiveness, and supply chain integrity of the United States in the field of microelectronics; and

(c) coordinate the policymaking process with respect to microelectronics related research, development, manufacturing, and supply chain security activities and budgets of Federal agencies and ensure such activities are consistent with the Strategy required by this section.

Sec. 5. General Provisions. (a) If any provision of this order or the application of such provision is held to be invalid, the remainder of this order and other dissimilar applications of such provision shall not be affected.

(b) This order is not intended to, and does not, create any right or benefit, substantive or procedural, enforceable at law or in equity by any party against the United States, its departments, agencies, or entities, its officers, employees, or agents, or any other person.

(c) Nothing in this order shall be construed to impair or otherwise affect:

(i) the authority granted by law to an executive department or agency, or the head thereof; or

(ii) the functions of the Director of the Office of Management and Budget relating to budgetary, administrative, or legislative proposals.

(d) This order shall be implemented consistent with applicable law and subject to the availability of appropriations.

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Chapter 14: Technology Protection

Blueprint for Action

This Blueprint for Action provides detail for how the United States must craft technology protection policies to ensure it retains existing advantages in technology areas with national security applicability but avoids stifling innovation. Promoting U.S. research, entrepreneurship, and talent development remain the key ingredients of success. However, as dual-use technologies become more important to U.S. national security, the margin of U.S. technological advantage narrows, and foreign efforts to acquire American know-how and technology increase, the United States must also reexamine how it can protect its commercial and academic ecosystem from foreign exploitation. The United States faces substantial challenges in adapting its technology protection regime to address threats related to emerging, dual-use technologies such as AI without hindering the free flow of commerce or its open research environment, both of which are systemic U.S. strengths. This Blueprint for Action proposes reforms for 1) modernizing export controls and investment screening and 2) protecting the U.S. research environment in ways which are consistent with U.S. national security, commercial interests, and values.

Modernizing Export Controls and Investment Screening

How the United States government regulates competitors' access to sophisticated U.S. technologies with national security applications will be one of the principal challenges of current and future geoeconomic competition. The United States must modernize its export control and investment screening regimes to better address the challenges posed by dual-use emerging technologies, to include AI. These reforms are necessary to allow the government to implement technology protection policies in ways which maximize their impact on the military capabilities of U.S. strategic competitors and minimize any resulting harms to U.S. industry.

Recommendation: Clearly State the Overarching Principles to Guide Future U.S. Dual-Use Technology Protection Policies

The United States government must clearly state the principles that will guide future U.S. decisions regarding policies to protect critical technologies. This will enable more consistent and cohesive technology protection policies, and provide clarity to industry regarding how the government intends to utilize these regulatory tools in the current competitive environment, thereby reducing uncertainty for U.S. businesses. No such framework currently exists.

Action for the President:

- **Issue an Executive Order outlining the principles which will guide U.S. policies for protecting dual-use technologies.**¹⁸⁴

¹⁸⁴ A draft text of such an Executive Order is included in an annex to this Blueprint for Action. This executive order also includes directives pertaining to most other export control-related recommendations in this Blueprint for Action.

- The President should issue an Executive Order (E.O.) to clarify guiding principles which will guide U.S. policies to protect critical dual-use technologies, including AI. The E.O. should include the following guiding principles:
 - U.S. technology controls will not supplant investment and innovation.
 - U.S. strategies to promote and protect U.S. technology leadership will be integrated and mutually reinforcing.
 - The United States will be judicious in applying export controls to AI-related technologies, targeting discrete chokepoints, and coordinating policies with allies.
 - The United States will broaden investment screening to protect AI-related technologies.

Recommendation: Enhance U.S. Capacity to Carry Out Effective Technology Protection Policies

Departments and agencies responsible for protecting U.S. technologies lack the organizational and technical capacity to design and implement effective policies to prevent the transfer of the national security-sensitive components of emerging technologies such as AI. They suffer from a dearth of technical talent needed to identify effective new policies and lack the analytical capacity to enforce their policies efficiently, especially on dual-use goods. Filling these gaps in key elements of the Executive Branch—particularly in the Departments of Commerce, the Treasury, and State—will enhance the government’s ability to craft targeted export controls that have the greatest strategic impact and the least harm on U.S. competitiveness.

Actions for the Department of Commerce:

- **Designate a network of FFRDCs and UARCs to serve as a shared technical resource on export controls.**¹⁸⁵
 - To deepen its internal technical expertise, the Department of Commerce should establish a network within existing federally funded research and development centers (FFRDCs) and university affiliated research centers (UARCs) to provide technical expertise to all departments and agencies for issues relating to export controls on emerging technologies. This network should be coordinated by the Department of Commerce and encompass a regional distribution of FFRDCs and UARCs that are either located in U.S. technology hubs or have significant expertise in emerging technologies.
 - As an initial step, the Department of Commerce should identify the FFRDCs and UARCs with existing expertise in emerging technologies under consideration for export controls. This should be followed by a request for funding in the Fiscal Year (FY) 2022 President’s Budget to support and expand work of FFRDCs and UARCs focusing on export controls.

¹⁸⁵ Additional details for this recommendation are also contained within the draft Executive Order included as an annex to this Blueprint for Action.

- **Require all new technology protection rules on emerging technologies to be coordinated with existing technical advisory groups that include outside experts.**¹⁸⁶
 - The Secretary of Commerce should require that the Bureau of Industry and Security solicit and receive feedback on any proposed controls on emerging or foundational technologies, to include proposed rules and regulations, from the Emerging Technology Technical Advisory Committee (ETTAC) and any other relevant technical advisory groups.¹⁸⁷ More frequent and effective use of such existing advisory committees would provide flexible technical expertise to key departments, help prevent publishing counterproductive controls, and ensure policymakers hear the perspective of industry and academia before controls go into effect.

Actions for the Departments of Commerce, the Treasury, and State:

- **Expedite and automate export licensing and CFIUS filing processes.**¹⁸⁸
 - The Departments of Commerce and the Treasury should partner with FFRDCs, UARCs, and other contracted entities to build an integrated, smart system for analyzing export license applications and filings with the Committee on Foreign Investment in the United States (CFIUS). This system should utilize AI to conduct a preliminary analysis of filings and attempt to score levels of risk before human review. In the near-term, this would help identify which transactions are very low risk and which are very high risk to aid subsequent human review. In the longer-term, it could prove more accurate than human review and make decisions without human involvement, allowing for precise, rapid, and less labor-intensive reviews.
- **Encourage allies to implement legal reforms authorizing them to implement unilateral export controls and enhance investment screening procedures.**
 - The Departments of State and Commerce must urge all allies which have not already done so to pass domestic legislation to overhaul their export control regimes, increasing their bureaucratic capacity and providing them the authorities to implement unilateral export controls. Currently, many allies lack such domestic legal authorities and instead defer all decisions about regulations to multilateral organizations such as the Wassenaar Arrangement and the European Union.¹⁸⁹

¹⁸⁶ Additional details for this recommendation are also contained within the draft Executive Order included as an annex to this Blueprint for Action.

¹⁸⁷ The ETTAC contains roughly 20 leading technical experts from prominent U.S. technology and defense firms, universities, and think-tanks. However, it has been under-utilized by Commerce; ETTAC did not hold a single meeting between June 2018 and May 2020. *Emerging Technology Advisory Committee*, Bureau of Industry and Security (last accessed Jan. 2, 2021), <https://tac.bis.doc.gov/index.php/ettac-home>.

¹⁸⁸ Additional details for this recommendation are also contained within the draft Executive Order included as an annex to this Blueprint for Action.

¹⁸⁹ The Wassenaar Arrangement, a multilateral body with 42 participating states, is the primary international forum responsible for aligning policies on dual-use export controls. However, because it operates by consensus and includes Russia, is slow to react to new technologies and developments, and is non-binding, the Wassenaar Agreement must not be the exclusive forum in which

These reforms are needed to allow allies to implement targeted, rapid, and effective export controls on emerging dual-use technologies which are evolving quickly. Technology protection regimes on globally available products are only as strong as their weakest link, necessitating U.S. cooperation with allies and strong allied regulatory capacity. This builds on existing work, which has been productive and should continue with an immediate focus on countries which have a strong domestic emerging technology base and weak regulatory regimes.¹⁹⁰

- The Departments of State and the Treasury should expedite efforts to enhance the investment screening capabilities of close allies and partners. Existing efforts have shown some success but now require increased urgency, given the threats allies face from adversarial capital and the U.S. desire to exempt some firms in allied nations from certain CFIUS requirements.¹⁹¹ State and the Treasury should also regularly share data about patterns in investment flows in the United States and allied countries to assist allied efforts to block predatory investments and illustrate the nature of the threat.
- **Ensure the offices responsible for export controls and investment screening policies have sufficient resources and technical capacity.**
 - The Departments of Commerce, the Treasury, and State must ensure that the offices responsible for designing and implementing export controls and investment screening provisions on emerging technologies are sufficiently resourced, and have sufficient technical capacity. Agencies should rely on external sources such as FFRDCs, UARCs, and advisory boards for deep technical expertise on particular technologies. However, they also must ensure that the offices principally responsible for managing the policy processes regarding controls on these technologies have adequate staffing, resources, and baseline technical capacity to keep pace with the rapidly evolving security challenges associated with dual-use technologies.

Recommendation: Identify “Emerging” and “Foundational” Technologies Which Must be Controlled, as Required by the Export Control Reform Act of 2018

The Export Control Reform Act of 2018 (ECRA) and the Foreign Investment Risk Review Modernization Act of 2018 (FIRRMA) are intended to overhaul the U.S. export control and investment screening regimes to better accommodate emerging technologies. ECRA requires the Department of Commerce to develop a regular, formal interagency process to identify “emerging

the United States and allies negotiate export control provisions on dual-use technologies. *About Us*, The Wassenaar Arrangement (last accessed Jan. 2, 2021), <https://www.wassenaar.org/about-us/>; *Second Quarter Recommendations*, NSCAI at 68-69 (2020), <https://www.nscai.gov/previous-reports/>.

¹⁹⁰ The Blueprint for Action and Annex associated with Chapter 15 of this report reinforce this recommendation and illustrate how these efforts should fit into a broader technology diplomacy strategy.

¹⁹¹ See Chris Darby, Gilman Louie, & Jason Matheny, *Mitigating Economic Impacts of the COVID-19 Pandemic and Preserving U.S. Strategic Competitiveness in Artificial Intelligence*, NSCAI at 14-15 (May 19, 2020), <https://www.nscai.gov/white-papers/covid-19-white-papers/>; *Second Quarter Recommendations*, NSCAI at 69; 75-77 (2020), <https://www.nscai.gov/previous-reports/>.

and foundational technologies that . . . are essential to the national security of the United States,” and are not otherwise controlled.¹⁹² Any such technologies identified by Commerce become subject to U.S. export controls, and any foreign investment in a U.S. company which “produces, designs, tests, manufactures, fabricates, or develops” one or more such technologies must be reviewed by CFIUS.¹⁹³ This list must be distinct from efforts within the Commission’s-proposed National Technology Strategy (NTS) to define emerging technologies key to U.S. national competitiveness and national security. The ECRA list must be more narrowly-defined and focused only on specific technologies for which export controls are necessary, whereas the TCC and NTS’ focus should be on identifying broader technologies and particular platforms in which continued U.S. leadership is essential.

However, as of March 2021, the Department of Commerce has yet to identify a single emerging or foundational technology as mandated by ECRA. While there is reason to be judicious in developing this list given its implications on U.S. industry, and Commerce faces legitimate capacity and resourcing limitations, the magnitude of the delay is unacceptable. The delay has garnered bipartisan criticism, created uncertainty for firms working in fields that could be labeled as emerging or foundational technologies, and delayed the government’s ability to either control the export of, or more importantly gain insight into transactions involving, critical technologies that are not otherwise controlled.¹⁹⁴

Identifying this list of technologies is critical to enabling the United States to fully implement both ECRA and FIRRMA. As ECRA and FIRRMA are structured, until the Department of Commerce defines a technology which is not otherwise controlled as “emerging and foundational” as part of this review process, with rare exceptions CFIUS cannot require foreign companies to disclose non-controlling investments in U.S. technology firms. Although the Commission also recommends breaking CFIUS’ reliance on this ECRA list for mandatory disclosures (see recommendations on reforming CFIUS for emerging technology competition, below), currently Commerce’s delay in identifying such technologies is hindering the full implementation of both ECRA and FIRRMA.

Action for the Department of Commerce:

- **Direct the Bureau of Industry and Security to develop proposed rules containing initial lists of both “emerging” and “foundational” technologies by December 31, 2021.**¹⁹⁵

¹⁹² 50 U.S.C. § 4817(a)(1)(A).

¹⁹³ 50 U.S.C. § 4565(a)(4)(B)(iii)(II); 85 Fed. Reg. 3112, *Provisions Pertaining to Certain Investments in the United States by Foreign Persons*, U.S. Department of Treasury: Office of Investment Security (Jan. 17, 2020) <https://www.federalregister.gov/documents/2020/01/17/2020-00188/provisions-pertaining-to-certain-investments-in-the-united-states-by-foreign-persons>.

¹⁹⁴ *New Controls on Emerging Technologies Released, While U.S. Commerce Department Comes Under Fire for Delay*, Gibson Dunn (Oct. 27, 2020), <https://www.gibsondunn.com/new-controls-on-emerging-technologies-released-while-us-commerce-department-comes-under-fire-for-delay/>; Letter from U.S. Senators Tom Cotton & Charles E. Schumer to Secretary Wilbur Ross, Department of Commerce, (Nov. 18, 2019), https://www.cotton.senate.gov/imo/media/doc/191118_Cotton_Schumer_ECRA%20Letter%20to%20Sec.%20Ross%20copy.pdf.

¹⁹⁵ Additional implementation details for this recommendation are also contained within the draft Executive Order included as an annex to this chapter.

- The Secretary of Commerce should direct the Bureau of Industry and Security to work with the U.S. interagency to develop initial versions of the lists of “emerging” and “foundational” technologies by December 31, 2021. Beyond 2021, these lists should be regularly revised in an iterative manner to meet ECRA’s mandate to Commerce to continually refine the lists. As part of this iterative review process, Commerce must also regularly engage with industry as technologies develop and mature. Finalizing initial versions of these lists, if properly scoped and defined, would control critical technologies, clarify to industry how Commerce intends to implement ECRA, and ensure that such technologies are included within CFIUS.

Recommendation: Reform CFIUS for Emerging Technology Competition

CFIUS is not currently postured to address the range of threats that the United States faces from adversarial capital from strategic competitors such as China and Russia. The Department of the Treasury has little insight into Russian and Chinese investments in U.S. emerging technology firms, as CFIUS filings are still largely voluntary for non-controlling investments in industries such as AI, semiconductors, quantum computing, and telecommunications equipment. While the Foreign Investment Risk Review Modernization Act of 2018 (FIRRMA) took positive steps in broadening CFIUS’ authorities, it also left critical gaps in the investment screening regime. Additional steps are necessary to enable CFIUS to protect sensitive U.S. industries from adversarial capital, while ensuring the continued free flow of capital from trusted investors from allied nations.

Action for Congress:

- **Amend CFIUS’ authorizing legislation to require competitors to disclose investments in “sensitive technologies” to CFIUS.**
 - Congress should amend CFIUS’ authorizing legislation to mandate CFIUS filings for all non-controlling investments from “countries of special concern” in “sensitive technologies.” The Commission recommends that the legislation:
 - Define “countries of special concern” as states subject to export restrictions pursuant to section 744.21 of title 15 within the Code of Federal Regulations (China, Russia, and Venezuela), or any state that the Secretary of State designates as a state sponsor of terrorism (Iran, North Korea, and Syria).¹⁹⁶
 - Require the Treasury Department to define a separate list of “sensitive technologies” for the purposes of CFIUS. Only investors from “countries of special concern” would be required to submit CFIUS filings for investments in “sensitive technologies.” Treasury currently lacks

¹⁹⁶ *State Sponsors of Terrorism*, U.S. Department of State (last accessed Jan. 2, 2021), <https://www.state.gov/state-sponsors-of-terrorism/>.

authorities to broaden CFIUS' mandatory filing requirements, which are linked to lists of technologies which are export controlled.¹⁹⁷

- Mandating CFIUS filings from select competitors in a broader set of sensitive industries—such as national security-relevant applications of AI, semiconductors, quantum computing, and advanced telecommunications equipment—will provide the Treasury with better visibility into Russian and Chinese investments in U.S. firms in key sectors. This allows CFIUS to operate with more precision and insight and focus attention on the riskiest investments.
- Additionally, de-linking CFIUS disclosure requirements from export controls recognizes there are instances in which it may be appropriate to screen investments prior to enacting export controls.¹⁹⁸ Without this change, the only way to increase such disclosure requirements would be to place export controls on entire industries, which would significantly hamper commerce.

Action for the Department of the Treasury:

- **Expedite CFIUS exemption standards for allies and partners and create fast tracks for exempting trusted investors.**
 - The Department of the Treasury should issue clear guidance for which investment screening policies allied nations must implement to achieve CFIUS exempted status.¹⁹⁹ Clearly defining the standards for investment screening mechanisms in foreign nations necessary for investors to be exempted from CFIUS will create a powerful incentive for allied nations to adopt stronger screening mechanisms against adversarial capital. The sooner the Treasury takes this action the more impact it will have on allied regulations. The Treasury should prioritize engagement with Five Eyes intelligence sharing partners, Japan, South Korea, India, Israel, Singapore, Taiwan, and the European Union to enable investment from allied nations in high tech U.S. firms.
 - Treasury should also issue new regulations creating a waiver for “trusted investors” from foreign countries who have a strong track record of CFIUS approval to exempt them from or lessen their CFIUS requirements. Currently there is no certification for investors with a trusted track record, and CFIUS treats foreign investors that are submitting for the first time the same as ones which have already submitted and been approved one hundred times. Creating such a

¹⁹⁷ As discussed in the following recommendation, due to the Department of Commerce's delay in identifying export controls on “emerging and foundational technologies” as required under the Export Control Reform Act of 2018 (ECRA), CFIUS' mandatory filing requirements have largely not expanded to emerging technology industries.

¹⁹⁸ For instance, for early-stage technology venture investments, particularly those which do not yet produce specific products, export controls have historically been ineffective, but investment screening would still have value. See Michael Brown & Pavneet Singh, *China's Technology Transfer Strategy*, Defense Innovation Unit Experimental at 24 (Jan. 2018), [https://admin.govexec.com/media/diux_chinatechnologytransferstudy_jan_2018_\(1\).pdf](https://admin.govexec.com/media/diux_chinatechnologytransferstudy_jan_2018_(1).pdf)

¹⁹⁹ CFIUS regulations released in January 2020 created an exception for non-controlling technology, infrastructure, and data (TID) investments for investors tied to “excepted foreign states,” with Australia, Canada, and the United Kingdom forming the initial list. The regulations require that excepted foreign states implement their own process to analyze foreign investments for national security risks and to facilitate coordination with the United States on investment screening by February 2022. However, Treasury has yet to publish the criteria CFIUS will use when determining whether additional countries can qualify as “excepted foreign states” in the future. See 31 C.F.R. 800.218 (2020), <https://home.treasury.gov/system/files/206/Part-800-Final-Rule-Jan-17-2020.pdf>.

waiver would allow CFIUS to fast-track investments from low-risk, trusted investors with a strong history of CFIUS approval, facilitating legitimate foreign investment and focusing CFIUS' resources on higher risk investments.

Recommendation: Utilize Targeted Export Controls on Key Semiconductor Manufacturing Equipment

Although the Commission believes that export controls on AI algorithms would likely be ineffective given their widespread availability and commercial use, export controls on specific hardware components are capable of constraining competitors' AI capabilities with national security applications, and slowing their advancement. Policymakers must be judicious in their application of such controls, as sweeping controls on general use semiconductors are likely to cause substantial damage to the U.S. semiconductor industry and could have a net negative effect on overall U.S. competitiveness in microelectronics. However, targeted controls on key components that only the United States—or the United States and a small group of close allies—produce which are essential for cutting-edge defense applications could have a significant strategic impact at a relatively minimal cost.

The primary target for such controls should be select, high-end semiconductor manufacturing equipment (SME) needed to produce high-end chipsets, particularly photolithography equipment.²⁰⁰ China is the world's largest importer of SME, accounting for 29% of global imports from 2014-2018, and none of the largest or most sophisticated SME manufacturing firms are located in China.²⁰¹ Simultaneous to implementing such controls, as discussed in Chapter 13 of this report the United States should also fund efforts to prioritize the domestic development and manufacturing of SME tools and components needed to produce chips at scale at the 3nm node and beyond.²⁰²

Action for the Departments of Commerce and State:

- **Align the export control policies of the United States, the Netherlands, and Japan to restrict the export of high-end SME to China, including EUV and ArF immersion lithography equipment.**²⁰³
 - The Departments of State and Commerce should work to align the export control policies of the United States, the Netherlands, and Japan regarding high-end SME, particularly EUV lithography equipment, and ArF immersion lithography equipment which is capable of producing chips at the 16nm node and below.²⁰⁴

²⁰⁰ The detailed reasons why high-end SME and photolithography equipment in particular represents the best target for such controls are described in Chapter 14 of this report.

²⁰¹ John Verwey, *The Health and Competitiveness of the U.S. Semiconductor Manufacturing Equipment Industry*, SSRN at 5, 8 (July 1, 2019), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3413951.

²⁰² See Chapter 13 of this report and its associated Blueprint for Action for additional details on recommendations to support the U.S. microelectronics industry, to include U.S. development of SME.

²⁰³ Additional details for this recommendation are also contained within the draft Executive Order included as an annex to this chapter.

²⁰⁴ EUV lithography equipment is the only type of lithography equipment capable of mass manufacturing chips at the 5nm node or potentially below. ArF immersion lithography equipment is the only other type of tool capable of mass producing chips at the 28nm node or below, with more sophisticated ArF immersion equipment capable of nodes under 16nm. See Saif Khan, *Securing*

All three states should establish a policy of presumptive denial of export licenses for exports of such equipment to China.²⁰⁵ This should include both EUV scanner tools, as well as specialized components for those tools such as resist processing tools and EUV light sources, mirrors, and laser amplifiers. If such controls are effective, it will be difficult for China's government to cultivate indigenous, cutting-edge semiconductor fabrication capabilities, and will degrade its advanced trailing-edge fabrication capabilities by complicating equipment repairs. Coupled with the refundable investment tax credit to promote U.S. semiconductor leadership recommended in Chapter 13 of this report, this will further the Commission's proposed U.S. policy goal of remaining two generations ahead of China in cutting-edge microelectronics design and fabrication.²⁰⁶

- **Assess the effectiveness of existing U.S. export controls on SME on China's semiconductor industry and assess whether targeted controls on additional equipment are viable and necessary.**
 - The Departments of Commerce and State should assess the effectiveness of existing U.S. export controls on SME on China's indigenous advanced semiconductor industry. Pending the results of that review and whether the Netherlands and Japan agree to align controls related to EUV and ArF immersion equipment, the United States could subsequently consider controls on additional SME chokepoints. If existing controls have failed to slow China's development of advanced fabrication capabilities, the United States could consider implementing controls on other targeted equipment chokepoints controlled by firms in allied countries, such as atomic layer etching tools in conjunction with Japan and the United Kingdom.²⁰⁷

Recommendation: Utilize End-Use Export Controls to Prevent Malicious Use of AI

Export controls which restrict transfer of dual-use items for specific end uses will not be effective at preventing technology transfer to determined adversaries, but they can still play a role in preventing the involvement of U.S. firms and technology in human rights abuses. For specific, high-end, dual-use equipment prone to facilitating uses of AI which enable human rights abuses, such as mass surveillance, U.S. firms should be required to certify that the equipment will not be used for specific nefarious ends, and keep logs of their transactions. End-

Semiconductor Supply Chains, Georgetown Center for Security and Emerging Technologies at 20 (Jan. 2021), <https://cset.georgetown.edu/research/securing-semiconductor-supply-chains/>.

²⁰⁵ In 2019, the United States put significant pressure on the Netherlands to block a sale of EUV lithography equipment from Dutch firm ASML to Chinese firm SMIC. The contract expired before the equipment was delivered, although the Netherlands has not stated whether or not it will approve future sales. See Alexandra Alper, et al., *Trump Administration Pressed Dutch Hard to Cancel China Chip-equipment Sale: Sources*, Reuters (Jan. 6, 2020), <https://www.reuters.com/article/us-asml-holding-usa-china-insight/trump-administration-pressed-dutch-hard-to-cancel-china-chip-equipment-sale-sources-idUSKBN1Z50HN>.

²⁰⁶ Increasing the competitiveness of the cutting-edge U.S. microelectronics fabrication industry would create new market opportunities for SME firms, which could offset any potential losses resulting from decreased access to the Chinese market due to export controls. This is particularly important for allied governments which may be hesitant to impose export controls on equipment which will hurt key domestic companies without simultaneously providing them access to new markets or growing existing markets.

²⁰⁷ Saif Khan, *Securing Semiconductor Supply Chains*, Georgetown Center for Security and Emerging Technologies at 20 (Jan 2021) <https://cset.georgetown.edu/research/securing-semiconductor-supply-chains/>.

use controls and reporting requirements would not substantially delay sales and present a lower barrier to commerce compared to list-based controls. Requiring companies to self-certify and self-report could deter U.S. firms from knowingly enabling bad behavior abroad.

Action for the Department of Commerce:

- **Implement end-use controls and reporting requirements to prevent the use of high-end U.S. AI chips in human rights violations**
 - The Department of Commerce should implement end-use controls on high-end U.S. designed or manufactured AI chips for use in mass surveillance applications, and institute reporting requirements on sales of such chips to China. The controls should be targeted only at very high-end or specialized chips, such as specific high-performing, GPUs, ASICs, or FPGAs which exceed a certain high performance threshold.²⁰⁸ Commerce would, by necessity, update this threshold as chips continue to improve.
 - Any firm which sells such chips to China should have to certify that it will not be used for any designated human rights abuses. Firms which sell such chips should also be required to provide quarterly reports to BIS listing all chip sales, in what quantity, and to which company. This will facilitate U.S. government tracking of chips which are most likely to facilitate abusive uses of AI and deter companies from selling chips to businesses which they know are engaging in such behavior.²⁰⁹

Protecting the U.S. Research Environment

The United States needs comprehensive and resourced interagency measures to counter adversarial threats to the U.S. research environment, especially from China. Efforts must be supported by technically-versed intelligence collection, analysis, and dissemination on threats in the Science and Technology space. Promising steps have been initiated through the National Counterintelligence Task Force and the Office of Science and Technology Policy.²¹⁰ However, it is imperative to holistically improve the way the government postures itself and equips the research community—in academia and the private sector—to counter threats and uphold the integrity of open research.

Recommendation: Build Capacity to Protect the Integrity of the U.S. Research Environment.

Actions for Congress:

²⁰⁸ GPUs are graphics processing units, ASICs are application-specific integrated circuits, and FPGAs are field programmable gate arrays.

²⁰⁹ The Blueprint for Action associated with Chapter 15 of this report reinforces this recommendation and illustrates how these efforts should fit into a broader technology diplomacy strategy.

²¹⁰ Specifically, the Joint Committee on Research Environments within the National Science and Technology Council. See *NSTC*, The White House (last accessed Jan. 1, 2021), <https://www.whitehouse.gov/ostp/nstc/>.

- **Pass a modified version of the Academic Research Protection Act.**²¹¹
 - Congress should pass the Academic Research Protection Act (ARPA) with a modification that would mandate and execute standardization of grant processes across federal research-funding agencies.²¹²
 - The ARPA would establish a National Commission on Research Protection; establish an open source intelligence clearinghouse relating to foreign threats to academia overseen by the Director of National Intelligence; improve guidance from the Departments of State and Commerce on export control responsibilities; and develop a Federal Bureau of Investigation (FBI) outreach strategy to promote information sharing on threats to the academic community.
 - The proposed modification would mandate development and implementation of a uniform application process and database across all Executive agencies that award research and development grants. This would enable effective oversight by grant-awarding agencies, allow for automated auditing, and support investigative efforts by federal law enforcement.

- **Establish a government-sponsored independent entity focused on research integrity.**
 - Congress should authorize the sponsorship of a University Affiliated Research Center (UARC) to act as a center of excellence on research integrity and provide information and advice on research security.
 - The entity should bridge the gap between the government and academic and private sector research institutions, and lower the barriers for research organizations to independently conduct compliance and informed risk assessments.
 - The UARC mandate should be to:
 - Maintain open source materials to serve university vetting of international engagement and risk management, including databases and risk assessment tools;
 - Provide tailored guidance to research organizations for decision support;
 - Conduct comprehensive studies and regular reports on the state of foreign influence on U.S. research;
 - Undertake independent investigations on research integrity;
 - Develop education materials and tools for U.S. research institutions to build annual training and compliance initiatives; and
 - Manage dialogue with stakeholder communities and provide a venue for information sharing.

²¹¹ H.R. 8346, Academic Research Protection Act, 116th Cong. (2020), <https://www.congress.gov/bill/116th-congress/house-bill/8346>.

²¹² This could mirror a provision for development of a uniform grant application process across research-funding agencies proposed in S. 3997, Safeguarding American Innovation Act, 116th Cong. (2020), <https://www.congress.gov/bill/116th-congress/senate-bill/3997/text>.

Action for the Director of National Intelligence:

- **Strengthen channels for information sharing with the research community.**
 - In concert with the open source intelligence clearinghouse relating to foreign threats to academia directed by the ARPA legislation, the Director for National Intelligence should support increased information and intelligence sharing with designated personnel at research organizations to share actionable information on specific threats. This would provide organizations the ability to swiftly take steps to mitigate risks.

Recommendation: Coordinate research protection efforts internationally with allies and partners.

The United States should build a coalition of like-minded nations committed to the principle of open fundamental research and the associated values of research integrity—sidelining nations and organizations that do not abide by the values that provide the foundation for international innovation and science cooperation.²¹³

Action for the Office of Science and Technology Policy:

- **Foster international dialogue around research protection and integrity.**
 - The Office of Science and Technology Policy, through the National Science and Technology Council, should work in coordination with Department of State's Office of Science and Technology Cooperation and Office of the Science and Technology Adviser to foster discussions with like-minded allies and partners focused on mitigating detrimental academic collaboration with China's People's Liberation Army (PLA)-affiliated and other high-risk entities. This should involve the establishment of an annual meeting of relevant education, science, and industry ministers to deepen research collaboration and coordinate on issues related to intellectual property and research security.

²¹³ Notably, two thirds of overseas professional associations that transfer technology to China are located outside the United States. See Ryan Fedasiuk & Emily Weinstein, *Overseas Professionals and Technology Transfer to China*, Center for Security and Emerging Technology at 2 (July 21, 2020) <https://cset.georgetown.edu/research/overseas-professionals-and-technology-transfer-to-china/>. One third of Thousand Talents awardees are located outside the United States, mainly in the UK, Germany, and Singapore. See Ryan Fedasiuk & Jacob Feldgoise, *The Youth Thousand Talents Plan and China's Military*, Center for Security and Emerging Technology at 4 (Aug. 2020), <https://cset.georgetown.edu/research/the-youth-thousand-talents-plan-and-chinas-military/>. Two thirds of awardees for some of China's largest scholarship programs are outside the United States. See Andrew Imbrie & Ryan Fedasiuk, *Untangling the Web: Why the US Needs Allies to Defend Against Chinese Technology Transfer*, Brookings Institution at 3 (Apr. 2020), <https://www.brookings.edu/research/untangling-the-web-why-the-us-needs-allies-to-defend-against-chinese-technology-transfer/>. Leaders in Canada, the Netherlands, UK, Japan, and India have in recent years publicly raised concerns around security risks related to research collaborations with China. Remco Zwetsloot, *China's Approach To Tech Talent Competition: Policies, Results, And The Developing Global Response*, Center for Security and Emerging Technology at 8 (Apr. 2020), <https://cset.georgetown.edu/research/chinas-approach-to-tech-talent-competition-policies-results-and-the-developing-global-response/>.

Action for the Department of Justice:

- **Strengthen information sharing venues.**
 - The Department of Justice (DOJ) and FBI, in coordination with Intelligence Community partners, should strengthen channels for information sharing on threats and best practices on research protection, and coordinate multilateral responses to enforce research security.

Action for the Department of State:

- **Reinforce global norms around a commitment to open fundamental research.**
 - Through international dialogues on research security and associated diplomacy, the Department of State should reinforce global norms around commitment to open fundamental research,²¹⁴ as described in the United States in the National Security Decision Directive-189, the *National Policy on the Transfer of Scientific, Technical and Engineering Information*.²¹⁵

Recommendation: Bolster Cybersecurity Support to Research Institutions.

Protection of research data and intellectual property from cyber-enabled theft is perhaps the most important and actionable layer of security for the U.S. research and development environment. This is particularly true for AI, when theft of training data or trained models essentially provides malicious actors access to a final product. Federal investments in priority emerging technology research areas such as AI should be accompanied by a requirement and support for institutions—whether academic or private sector—to implement cybersecurity measures that adequately guard research data from cyber-enabled theft.

Actions for U.S. grant-making agencies:

- **Incentivize cybersecurity standards and best practices for grant-receiving research institutions.**
 - U.S. grant-making agencies should provide incentives to research institutions to ensure that necessary practices, based on the existing NIST cybersecurity

²¹⁴ This could build on a concept currently under consideration by the National Science Foundation to establish and formalize an international code of conduct around shared principles in research integrity and then fund collaborative research in accordance with said principles.

²¹⁵ The directive defines fundamental research as: “‘Fundamental research’ means basic and applied research in science and engineering, the results of which ordinarily are published and shared broadly within the scientific community, as distinguished from proprietary research and from industrial development, design, production, and product utilization, the results of which ordinarily are restricted for proprietary or national security reasons.” The key provision of NSDD-189 remains today: “It is the policy of this Administration that, to the maximum extent possible, the products of fundamental research remain unrestricted. It is also the policy of this Administration that, where the national security requires control, the mechanism for control of information generated during federally-funded fundamental research in science, technology and engineering at colleges, universities and laboratories is classification.” *National Policy on the Transfer of Scientific, Technical And Engineering Information*, NSDD-189 (Sept. 21, 1985), <https://fas.org/irp/offdocs/nsdd/nsdd-189.htm>.

framework,²¹⁶ as well as governance processes are in place to protect sensitive research data.

- Reporting structures and information flows of research institutions should be structured to raise cybersecurity as a critical issue for senior management and facilitate internal checks and audits. This includes senior leadership awareness of cyber threats, risk assessments, and active preventive measures,
 - U.S. grant-making agencies should make available incentives for research institutions that demonstrate adherence to cybersecurity standards and best practices.
 - Universities, research institutions, and other recipients of federal research funding should be required to periodically demonstrate that they are adhering to cybersecurity best practices. For government-owned and sponsored laboratories, adherence to best practices, such as requiring critical data to be encrypted at rest and in transit, should be mandated and audited on a routine basis.
- **Support increased information sharing.**
 - Research institutions receiving federal research dollars and who do not already participate in should be encouraged to join the Research and Education Networks Information and Sharing Analysis Center (REN-ISAC)²¹⁷ or an alternate ISAC, through which they can share information on threats and mitigation, benefit from automated threat sharing tools, and have access to peer assessment services to strengthen security postures.
 - Similarly, research institutions should be made aware and encouraged to take advantage of the cybersecurity services offered by the Department of Homeland Security's Cybersecurity and Infrastructure Security Agency (CISA), to include automated indicator sharing²¹⁸ and enhanced cybersecurity services.²¹⁹

Action for the Federal Bureau of Investigation:

- **Share real-time, actionable threat information with research institutions.**
 - The FBI Cybersecurity Division should work closely with and share timely, anonymized threat information with REN-ISAC and research institutions to help them take active measures to counter cyberattacks and mitigate vulnerabilities.

²¹⁶ *Cybersecurity Framework*, NIST (last accessed Feb. 1, 2021), <https://www.nist.gov/cyberframework>.

²¹⁷ REN-ISAC (last accessed Jan. 2, 2021), <https://www.ren-isac.net/>.

²¹⁸ *Automated Indicator Sharing*, Cybersecurity and Infrastructure Security Agency (last accessed Feb. 10, 2021), <https://www.cisa.gov/automated-indicator-sharing-ais>.

²¹⁹ *Enhanced Cybersecurity Services (ECS)*, Cybersecurity and Infrastructure Security Agency (last accessed Feb. 10, 2021), <https://www.cisa.gov/enhanced-cybersecurity-services-ecs>.

Action for the Department of Homeland Security:

- **Support research cybersecurity information sharing similar to that of critical infrastructure.**
 - The Department of Homeland Security, CISA, National Cybersecurity and Communications Integration Center²²⁰ should support the level of information sharing with research institutions as they do with critical infrastructure and the Financial Services ISAC.²²¹

Action for the Office of Science and Technology Policy:

- **Support secure data storage.**
 - OSTP should broker commercial cloud credits²²² for universities to establish an ability to support secure data storage for research groups and laboratories conducting work known to be of high interest to foreign adversaries. This would provide an ability for universities to protect their sensitive research in a manner that does not require a significant capital investment.

Recommendation: Counter Foreign Talent Recruitment Programs.

China uses foreign talent recruitment programs to achieve a “high ground” of AI experts.²²³ Rather than pursue legitimate competition for scientific talent through attractive job offers, China’s talent recruitment plans are designed in a manner that contradicts U.S. norms of research integrity, violates rules around disclosure, and creates vectors for technology transfer.²²⁴ The FBI and intelligence community assess that “participants are often incentivized to transfer to China the research they conduct in the United States, as well as other proprietary information to which they can gain access.”²²⁵ There is an urgent need to reinforce standards around disclosure of conflicts of interest and commitment, and to create mechanisms that enable a heightened level of

²²⁰ *Cyber Incident Response*, Cybersecurity and Infrastructure Security Agency (Oct. 27, 2020), <https://www.cisa.gov/cyber-incident-response>.

²²¹ *Information Sharing and Awareness*, Cybersecurity and Infrastructure Security Agency (Dec. 8, 2020), <https://www.cisa.gov/information-sharing-and-awareness>.

²²² The National Science Foundation’s Cloudbank program could be leveraged as a model, see Cloudbank, <https://www.cloudbank.org/>.

²²³ William C. Hannes & Huey-meei Chang, *China’s Access to Foreign AI Technology*, Center for Security and Emerging Technology at 9-10 (Sept. 2019), https://cset.georgetown.edu/wp-content/uploads/CSET_China_Access_To_Foreign_AI_Technology.pdf.

²²⁴ The Office of Science and Technology Policy defines foreign government talent recruitment programs as “an effort directly or indirectly organized, managed, or funded by a foreign government to recruit science and technology professionals or students (regardless of citizenship or national origin).” *Enhancing the Security and Integrity of America’s Research Enterprise*, Office of Science and Technology Policy at 18 (June 2020), <https://trumpwhitehouse.archives.gov/wp-content/uploads/2020/07/Enhancing-the-Security-and-Integrity-of-Americas-Research-Enterprise.pdf>.

²²⁵ Testimony of John Brown, Assistant Director Counterintelligence Division, Federal Bureau of Investigation, delivered before the U.S Senate Committee On Homeland Security And Governmental Affairs, Permanent Subcommittee On Investigations, *Hearing on Securing the U.S. Research Enterprise from China’s Talent Recruitment Plans* at 2 (Nov. 19, 2019), <https://www.hsgac.senate.gov/imo/media/doc/Brown%20Testimony.pdf>. In some cases, the Chinese government appears to have rewarded scientists caught stealing technology through talent-recruitment programs, Alex Joske, *Hunting the Phoenix*, Australian Strategic Policy Institute at 8 (2020), <https://www.jstor.org/stable/resrep26119.1>.

transparency and accountability.²²⁶ This applies to researchers' individual transparency and institutional accountability, and to the government in identifying problematic affiliations and enforcing standards. Currently, U.S. grant-making agencies lack common processes, coordination, and compliance mechanisms to enable this level of transparency and effective oversight.²²⁷

Action for the Office of Science and Technology Policy:

- **Standardize grant application and recording processes.**
 - The Office of Science and Technology Policy, in coordination with the Office of Management and Budget, should provide advice and coordination to the Executive Branch to make uniform the grant application and recording processes across Federal agencies that fund external research.
 - OSTP should advise and coordinate with agencies to ensure agencies embrace a government-wide standard for grant proposal documentation, requiring machine-readable formats that facilitate automation to identify fraud.²²⁸ This would enable effective oversight by grant-awarding agencies, allow for automated auditing, and support investigative efforts by federal law enforcement.

Actions for Congress:

- **Mandate and resource compliance operations.**
 - Congress should require and resource U.S. grant-making agencies to maintain compliance operations that can enforce standardized disclosure and accountability measures. Through periodic vetting and monitoring, grant-making agencies can provide a layer of accountability to enforce disclosure and protection policies.²²⁹
- **Amend the Foreign Agent Registration Act.**
 - Congress should amend Foreign Agent Registration Act (FARA)²³⁰ to require any individual or entity involved in the recruitment of U.S. nationals for a foreign

²²⁶ A National Science Foundation-commissioned JASON study on fundamental research security found that “disclosure of activities presents our main defense against foreign influence, especially that involving rewards, deception, and coercion.” *Fundamental Research Security*, JASON at 31 (Dec. 6, 2019), https://www.nsf.gov/news/special_reports/jasonsecurity/JSR-19-2IFundamentalResearchSecurity_12062019FINAL.pdf.

²²⁷ *Threats to the U.S. Research Enterprise: China's Talent Recruitment Plan*, U.S. Senate Permanent Subcommittee on Investigations, (Nov. 2019), <https://www.hsgac.senate.gov/imo/media/doc/2019-11-18%20PSI%20Staff%20Report%20-%20China's%20Talent%20Recruitment%20Plans.pdf>.

²²⁸ This mirrors a recommendation from the U.S. Senate Permanent Subcommittee on Investigations. See *Threats to the U.S. Research Enterprise: China's Talent Recruitment Plan*, U.S. Senate Permanent Subcommittee on Investigations at 11 (Nov. 2019), <https://www.hsgac.senate.gov/imo/media/doc/2019-11-18%20PSI%20Staff%20Report%20-%20China's%20Talent%20Recruitment%20Plans.pdf>.

²²⁹ The National Institutes of Health's recent investments in this capability could serve as a model for others, scaled in terms of an agency's level of funding.

²³⁰ 22 U.S.C. § 611 et seq.

talent program²³¹ to register as a foreign agent. This requires Congress to add a new category of activity to the legislation.

Actions for Department of Justice:

- **Update filing regulations to support an amended FARA.**
 - Should Congress amend FARA legislation as proposed above, DOJ, in its implementing regulations, should identify specific information required from individuals involved in recruitment for foreign talent programs to ensure that the U.S. government has adequate visibility into foreign countries' talent recruitment activities in the United States.
 - DOJ regulations should include methods for individuals and organizations to appeal a determination that they are subject to registration under this FARA expansion.
- **Publicly identify U.S.-based entities and foreign government proxies that serve as recruitment networks, platforms, or brokers.**
 - To help raise awareness among researchers and research institutions, and reinforce transparency, Federal law enforcement and other relevant agencies should identify entities involved in recruitment activities for foreign talent programs and require their registration through the FARA (if amended).
 - This effort must be accompanied by an associated appeal process for organizations to contest the need to register from identification.

Recommendation: Limit collaboration with PLA-affiliated persons and entities.

PLA-affiliated universities and research labs send personnel abroad, with the overarching aim to obtain knowledge that can directly feed defense research and development priorities. Visiting scholars or students from PLA institutions often downplay their ties to the military or deliberately obscure affiliation by using alternate, external names for their home institutions that do not mention military or defense mandates.²³²

The government should take actions through designation of institutions of concern and heightened visa vetting to assist universities in making risk assessments around research collaborations—becoming an effective partner in protecting research integrity.

Action for the Director of National Intelligence:

²³¹ This will require a clear definition of a foreign talent program, distinct from standard internationally-funded research opportunities. The Office of Science and Technology Policy defines foreign government talent recruitment programs as “an effort directly or indirectly organized, managed, or funded by a foreign government to recruit science and technology professionals or students (regardless of citizenship or national origin).” *Enhancing the Security and Integrity of America’s Research Enterprise*, Office of Science and Technology Policy at 18 (June 2020), <https://trumpwhitehouse.archives.gov/wp-content/uploads/2020/07/Enhancing-the-Security-and-Integrity-of-Americas-Research-Enterprise.pdf>.

²³² Glenn Tiffert, *Global Engagement: Rethinking Risk In The Research Enterprise*, The Hoover Institution at 12 (2020), https://www.hoover.org/sites/default/files/research/docs/tiffert_globalengagement_full_0818.pdf.

- **Create an open source database of organizations that have a history of improper technology transfer, intellectual property theft, or cyber espionage.**²³³
 - The Director of National Intelligence, in coordination with law enforcement partners, should create a queryable database of academic institutions and other organizations that have a history of improper technology transfer, intellectual property theft, or cyber espionage. This resource should serve the research community and inform risk assessments of research organizations when entering collaborative arrangements. It would represent an expansive, open source view of research institutions of concern, countering efforts to obscure military affiliations through adoption of innocuous institutional aliases.
 - This must be accompanied by an associated appeal process for organizations to contest their inclusion in the database.

Action for the President:

- **Limit entrance of researchers with military and intelligence affiliations from countries of concern.**
 - The President should issue an order to the Secretary of State and Secretary of Homeland Security to implement a requirement for special review of visas for advanced degree students and researchers with ties to research institutions affiliated with foreign military and intelligence organizations of designated countries of concern.²³⁴
 - This should be paired with penalties that ban entry to any visa applicants found to have intentionally obscured institutional affiliations.

Action for the Department of State:

- **Resource special review measures.**
 - Consular officers should be provided with adequate training, reference resources, analytical support, and time to conduct the special review.

²³³ If Congress passes the Academic Research Protection Act, this initiative could be a component of the open source intelligence clearinghouse on threats to academia created through the legislation.

²³⁴ This is recommended as an update to Presidential Proclamation 10043 that automatically suspends F or J visas to study or conduct research for Chinese nationals affiliated with the Chinese government military-civil fusion strategy. See Donald J. Trump, *Proclamation on the Suspension of Entry as Nonimmigrants of Certain Students and Researchers from the People's Republic of China*, The White House (May 29, 2020), <https://trumpwhitehouse.archives.gov/presidential-actions/proclamation-suspension-entry-nonimmigrants-certain-students-researchers-peoples-republic-china/>. This order would provide for a case-by-case, risk-based review of potentially concerning applications from a broader group of designated countries.

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Chapter 14 Annex: Technology Protection

Draft Executive Order on Export Control on Principles Guiding U.S. Policies for Protecting Dual-use Technologies

By the authority vested in me as President by the Constitution and the laws of the United States of America, and in order to promote U.S. innovation and leadership in emerging and foundational technologies while protecting U.S. national security, it is hereby ordered as follows:

Section 1. *Policy.* It is the policy of the United States that export controls and investment screening mechanisms must be used in targeted, clearly defined, and strategic ways to protect U.S. national security, in pursuit of the broader policy of promoting U.S. innovation and leadership in emerging and foundational technologies, to include dual-use technologies such as artificial intelligence (AI).

The United States must be tailored and discrete in implementing export controls on dual-use emerging technologies, such as AI. To ensure maximum effectiveness and minimize the adverse impact on U.S. industry, the United States Government should be guided by the following principles:

(1) Principle One: Export Controls Cannot Supplant Investment and Innovation.

Technology protection policies are intended to slow U.S. competitors' pursuit and development of key strategic technologies for national security purposes, not stop them in their tracks. The United States must cultivate investment in these technologies through direct federal funding or changes to the regulatory environment in order to preserve existing U.S. advantages.

(2) Principle Two: U.S. Strategies to Promote and Protect U.S. Technology Leadership Must Be Integrated.

The U.S. strategy to protect emerging technologies, including but not limited to AI, must be integrated with targeted efforts to promote U.S. leadership in such technologies. When choosing to implement controls, the United States should simultaneously consider policies to spur domestic research and development (R&D) in key industries to partially offset the resulting costs to U.S. firms, create alternative global markets, or encourage new investment to strengthen the U.S. industrial position.

(3) Principle Three: Export Controls Must Be Targeted, Strategic, and Coordinated with Allies.

In devising new export controls on widespread and dual-use technologies such as AI, the United States must be careful and selective in the implementation of export controls. To ensure maximum effectiveness and minimize the adverse impact on U.S. industry, the United States Government should be guided by the following three-part test:

- a. Export controls must be targeted, clearly defined, and focused on choke points where they will have a strategic impact on the national security capabilities of competitors, but smaller repercussions on U.S. industry.

b. Export controls must have a clear strategic objective, seeking to deter competitors from pursuing paths that endanger U.S. national security interests, and account for the projected cost and timeframe for competitors to create a domestic alternative.

c. Export controls must be coordinated with key U.S. allies which are also capable of producing the given technology, in order to effectively restrict the supply to adversaries and also prevent circumstances where unilateral controls cut off U.S. market access but competitors are able to purchase the same technology from other countries.

(4) Principle Four: The United States will be judicious in its use of export controls, but broaden investment screening on critical and emerging technologies. While broad and sweeping export controls on AI and other dual-use emerging technologies could result in significant blowback on U.S. industry, which would harm overall U.S. strategic competitiveness, investment screening presents opportunities to take a more proactive regulatory approach while minimizing risk to U.S. industry. Provided the United States can continue approving benign transactions expeditiously, enhancing investment screening presents significant potential to blunt concerning transfers of technology.

Section 2. *Objective.* In 2018, the Congress enacted the Export Control Reform Act of 2018 (ECRA) and the Foreign Investment Risk Reduction Modernization Act of 2018 (FIRRMA) to provide the United States Government with additional mechanisms to control exports and screen investments. The United States Government must take steps to provide the private sector and foreign governments with clarity about the application of these laws to emerging and foundational technologies and enhance U.S. national security in the process.

Section 3. *Establishment of Interagency Task Force on Emerging and Foundational Technologies.* (a) Pursuant to Section 1758 of ECRA, there is hereby established an Interagency Task Force on Emerging and Foundational Technologies (Task Force) to identify emerging and foundational technologies that are essential to the national security of the United States and are not critical technologies described in clauses (i) through (v) of 50 U.S.C. 4565(a)(6)(A).

(b) The Task Force shall be chaired by the Secretary of Commerce (Chair) and consist of senior-level officials from the following executive departments and agencies (agencies) designated by the heads of those agencies:

(i) Department of State;

(ii) Department of the Treasury;

(iii) Department of Defense;

(iv) Department of Energy; and

(vi) such other agencies as the President, or the Chair, may designate.

(c) The Chair shall designate a senior-level official of the Department of Commerce as the Executive Director of the Task Force, who shall be responsible for regularly convening and presiding over the meetings of the Task Force, determining its agenda, and guiding its work in fulfilling its functions under this Order, in coordination with the Bureau of Industry and Security (BIS) at the Department of Commerce.

Section 4. *Functions of the Task Force.*

(a) The Task Force shall meet regularly to identify emerging and foundational technologies that are essential to the national security of the United States for purposes of establishing export controls and investment screening mechanisms, as appropriate, related to those technologies.

(b) Within 120 days, the Task Force shall finalize lists of emerging and foundational technologies pursuant to section 1758 of ECRA. The Secretary of Commerce shall thereafter issue proposed rules on emerging and foundational technologies and proceed expeditiously to issue final rules at the conclusion of the notice and comment period.

(c) The Task Force shall review the lists of emerging and foundational technologies and issue amendments as needed on no less than an annual basis.

Section 5. *Process for Identifying Emerging and Foundational Technologies.* (a) In identifying emerging and foundational technologies pursuant to this Order, the Task Force shall consider information from multiple sources, including:

(i) publicly available information;

(ii) classified information, including relevant information provided by the Director of National Intelligence;

(iii) information relating to reviews and investigations of transactions by the Committee on Foreign Investment in the United States under 50 U.S.C. 4565; and

(iv) information provided by the advisory committees established by the Secretary to advise the Under Secretary of Commerce for Industry and Security on controls under the Export Administration Regulations, including the Emerging Technology Technical Advisory Committee (ETTAC).

(b) In identifying emerging and foundational technologies pursuant to this Order, the Task Force shall take into account:

(i) the development of emerging and foundational technologies in foreign countries;

(ii) the effect export controls imposed pursuant to this section may have on the development of such technologies in the United States;

(iii) the effectiveness of export controls imposed pursuant to this section on limiting the proliferation of emerging and foundational technologies to foreign countries; and

(iv) the policy and principles reflected in section 1 of this Order.

Section 6. Improving Coordination with Expert Advisory Groups. (a) The Secretary of Commerce shall review existing technical advisory committees (TACs) at the Department of Commerce, including the ETTAC, to ensure that each TAC is comprised of members from industry and academia with deep subject matter expertise to assess the need for export controls for emerging and foundational technologies.

(b) The Secretary of Commerce, as Chair of the Task Force, shall ensure that the Task Force has solicited and received feedback from the ETTAC and other relevant TACs at the Department of Commerce on the text of any proposed or final rule on emerging or foundational technologies, prior to issuance of such rule.

(c) The Secretary of Commerce shall ensure that senior officials at the Departments of State and the Treasury are granted non-voting observer access at all ETTAC meetings.

Section 7. Improving International Coordination on Export Controls on Semiconductor Manufacturing Equipment. Within 180 days, the Secretary of State, in consultation with the Secretary of Commerce and the Secretary of Defense, shall host a multilateral engagement with senior-level representatives of Japan, the Netherlands, and if deemed appropriate, other U.S. allies and partners that produce semiconductor manufacturing equipment, including EUV lithography equipment and ArF immersion lithography equipment, listed by the Wassenaar Arrangement or identified by the Task Force. The purpose of this meeting will be to align export licensing policies toward a presumptive denial of export licenses for exports of semiconductor manufacturing equipment to China. The Secretary of State shall provide a report to the President within 60 days of the meeting assessing:

(i) whether U.S. allies and partners are currently exporting such equipment to China;

(ii) what steps each country which manufactures such equipment must take to ensure its regulatory regime is aligned with that of the United States, and its willingness to take those steps; and

(iii) whether additional opportunities exist to strengthen international cooperation on export controls on semiconductor manufacturing equipment which are consistent with the policy and principles reflected in section 1 of this Order.

Section 8. Engaging Technical Experts for Export Control Review. (a) The Secretary of Commerce, in consultation with the Secretaries of the Treasury and Defense, shall establish a network within existing federally funded research and development centers (FFRDCs) and university affiliated research centers (UARCs) to provide technical expertise to all departments

and agencies for issues relating to export controls and investment screening related to emerging and foundational technologies. The network shall encompass a regional distribution of FFRDCs and UARCs located in areas of the United States with a concentration of technology expertise in emerging and foundational technologies.

(b) Individuals selected to participate in the network shall provide real-time technical input to all policy discussions on export controls and review of export control license applications, including those of the Task Force, those conducted pursuant to EO 12981 or a successor order, and any other interagency policy discussions pertaining to export controls, as well as the investment screening processes of the Committee on Foreign Investment in the United States (CFIUS).

Section 9. *Automating Export Control and Investment Screening Reviews.* The Secretaries of Commerce and the Treasury shall task the aforementioned network with exploring using AI-based systems to assist in the evaluation of applications for export control licenses and CFIUS filings and shall provide a report to the President on the use of AI-based systems for such purposes within 180 days. This report shall include an evaluation of:

- (i) how AI-based systems could assist existing review processes;
- (ii) whether incorporating such systems could enhance the accuracy and speed of the review processes;
- (iii) whether relevant Departments and Agencies have sufficient quantity and quality of data to train AI-based review systems, and how existing data can be improved;
- (iv) what information technology infrastructure inside relevant Departments and Agencies needs to be improved to fully utilize such systems; and
- (iv) an approximate timeline and cost for deploying a system or systems, and the projected savings per year in labor-hours once deployed.

Section 10. *General Provisions.* (a) Nothing in this order shall be construed to impair or otherwise affect:

- (i) the authority granted by law, regulation, Executive Order, or Presidential Directive to an executive department, agency, or the head thereof; or
- (ii) the functions of the Director of the Office of Management and Budget relating to budgetary, administrative, or legislative proposals.

(b) This order shall be implemented consistent with applicable law and subject to the availability of appropriations.

(c) This order is not intended to, and does not, create any right or benefit, substantive or procedural, enforceable at law or in equity by any party against the United States, its departments, agencies, or entities, its officers, employees, or agents, or any other person.

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Chapter 15: A Favorable International Technology Order Blueprint for Action

This Blueprint for Action provides detail for a comprehensive strategy to further U.S. interests with allies and partners to shape a favorable international technology order, win the technology competition against authoritarian states, and advance AI innovation and adoption across the world to promote the values of free and open societies. This Blueprint for Action also proposes reforms to reorient U.S. foreign policy and the Department of State for great power competition in the digital age.

Recommendation: Develop an International Science & Technology Strategy

The International Science & Technology Strategy (ISTS) will help coordinate emerging technology policies across the government and with our closest allies and partners; apply the tools of foreign assistance, technical expertise and guidance, and development finance and investment; and foster collaborative R&D. The ISTS should serve as the international component of the National Technology Strategy and provide an organizing framework to drive U.S. foreign policy with regard to emerging technologies.²³⁵ The ISTS should center on four big initiatives:

- Building an Emerging Technology Coalition (ETC);
- Launching an International Digital Democracy Initiative (IDDI);
- Implementing a coordinated U.S. national plan to support international efforts; and
- Enhancing the United States' position as an international digital research hub.

Action for the President:

- **Direct development of an International Science & Technology Strategy (ISTS) by a White House-led interagency task force.**
 - The President should direct development of the ISTS by a dedicated task force.
 - The ISTS Task Force should be convened by the Technology Competitiveness Council or otherwise co-chaired by the Assistant to the President for National Security Affairs and the Directors of the Office of Science and Technology Policy and the National Economic Council.
 - The ISTS Task Force should include leadership from the following agencies:
 - the Department of State;
 - the Department of the Treasury;
 - the Department of Commerce, including the Bureau of Industry and Security (BIS) and the National Institute of Standards and Technology (NIST);
 - the Department of Energy (DOE);
 - the Department of Homeland Security's Cybersecurity & Infrastructure Security Agency (CISA);
 - the National Science Foundation (NSF);

²³⁵ For more information on the National Technology Strategy, see Chapter 9 of this report.

- the United States Agency for International Development (USAID);
 - the U.S. International Development Finance Corporation (DFC);
 - the Export-Import Bank of the United States (EXIM);
 - the U.S. Trade and Development Agency (USTDA);
 - the Millennium Challenge Corporation (MCC); and
 - as appropriate, other agencies with expertise on individual topics.
- The ISTS Task Force should develop and submit to the President a formal strategy, linked closely to the President’s National Security Strategy (NSS), and the Secretary of State’s and USAID Administrator’s Joint Strategic Plan (JSP), building on those documents’ technology-related goals and priorities. The ISTS should serve as the international component of the National Technology Strategy.²³⁶
 - The ISTS should be centered around four big initiatives addressed in this Plan:
 - building an Emerging Technology Coalition;
 - launching an International Digital Democracy Initiative;
 - implementing a comprehensive U.S. national plan to support international digital efforts around technical standards, foreign assistance, development finance, and export controls; and
 - enhancing the United States’ position as an international digital research hub.
 - Once approved by the President, the ISTS Task Force would be responsible for overseeing and supporting the implementation, to include identifying resource and organizational changes needed to implement the strategy. The ISTS Task Force should hold regular meetings to facilitate execution of the strategy.

Recommendation: Build an Emerging Technology Coalition

As part of the ISTS, the United States, led by the White House and the Department of State, should lead in forming an **Emerging Technology Coalition (ETC)** of countries respectful of democratic values. The ETC would be a body of like-minded allies and partners to work with each other and with help from international and non-governmental organizations, civil society actors, and the private sector to develop and implement a coordinated strategy and associated policies to:

1. promote the design, development, and use of emerging technologies according to democratic norms and values;
2. coordinate policies and investments to counter the malign use of these technologies by authoritarian regimes; and
3. provide concrete, competitive alternatives to counter the adoption of digital infrastructure made in China.

Action for the White House and the Department of State:

- **Convene key allies and partners to join and establish the ETC.**

²³⁶ See Chapter 9 of this report for more details.

- The United States should lead an ETC of like-minded nations either as part of a larger democracy summit or as a stand-alone endeavor.
- Membership should include a core group of technologically advanced democratic nations, reflecting a broad geographic distribution, that have demonstrated shared interests in advancing responsible AI, countering malign uses of emerging technologies, and ensuring high standards for openness, trust, and privacy in digital infrastructure.
 - The ETC should build on two important dialogues previously recommended by the Commission: the **U.S.-India Strategic Tech Alliance** and the **U.S.-EU Strategic Dialogue for Emerging Technologies**.²³⁷
 - The ETC should build on—and be additive to—promising efforts and projects underway at the Organization for Economic Co-Operation and Development (OECD) and Global Partnership on AI (GPAI).²³⁸
- The Commission further recommends that the ETC invites representatives from international organizations, non-governmental organizations, civil society, academia, and the private sector.
 - These organizations are critical to implement policies across borders, convene state and non-state actors, and promote alignment of responsible AI and digital infrastructure development and use in accordance with shared democratic values.²³⁹
 - They should be included in the ETC, among participants in the inaugural session, and should have observer status.

Actions for the United States and Allies and Partners:

- **Organize efforts to synchronize policies and initiatives across seven critical areas.**
 - The ETC should be organized around a concrete agenda with actionable objectives focused on the outcomes rather than processes, designed to develop and realize a shared vision of a positive technological future and contrast it against a future dominated by authoritarian practices.
 - Building on an existing framework of guiding principles, such as the OECD AI Principles,²⁴⁰ members should use the inaugural meeting to endorse a concrete agenda designed to operationalize policies and initiatives across seven critical areas:

²³⁷ See *Interim Report and Third Quarter Recommendations*, NSCAI at 214-218 (Oct. 2020), <https://www.nscai.gov/previous-reports/>.

²³⁸ The Commission supports these efforts and further encourages the U.S. government to engage proactively through a “mosaic approach” to ensure the Emerging Technology Coalition is additive and not duplicative. See *Interim Report and Third Quarter Recommendations*, NSCAI at 185 (Oct. 2020), <https://www.nscai.gov/previous-reports/>.

²³⁹ Key organizations for membership include the OECD, the Council of Europe (through the Ad Hoc Committee on AI), the Freedom Online Coalition, GPAI, and the North Atlantic Treaty Organization. The United States and other core partner states should consider including international organizations as observers (e.g. the World Bank, the International Monetary Fund, the World Intellectual Property Organization, the World Health Organization, the World Trade Organization, and United Nations Educational, Scientific, and Cultural Organization).

²⁴⁰ *Recommendation of the Council on Artificial Intelligence*, OECD (May 21, 2019), <https://legalinstruments.oecd.org/en/instruments/OECD-LEGAL-0449>.

- *Developing and operationalizing standards and norms*, in support of democratic values and the development of secure, reliable, and trusted technologies;
 - *Promoting and facilitating coordinated and joint R&D on AI and digital infrastructure* that advances shared interests and benefits humanity;
 - *Promoting democracy, human rights, and the rule of law* through joint efforts to counter censorship, malign information operations, human trafficking, and illiberal uses of surveillance technologies;
 - *Exploring ways to facilitate data sharing* among allies and partners through enabling agreements, common data archival procedures, cooperative investments in privacy-enhancing technologies, and addressing legal and regulatory barriers;
 - *Promoting and protecting innovation*, particularly through export controls, investment screening, supply chain assurance, emerging technology investment, trade policy, research and cyber protections, and intellectual property alignment;
 - *Developing AI-related talent*, by analyzing labor market challenges, harmonizing skills and certification requirements, and increasing talent exchanges, joint training, and workforce development initiatives; and
 - *Launching the International Digital Democracy Initiative* to coordinate international foreign assistance, development aid and financing, technical guidance, and policy guidance.
- To execute an agenda across the seven critical areas, the ETC members should consider creating implementation groups for each area.
 - Proposed agendas and guidance for each critical area are included in the Emerging Technology Coalition Annex to this Blueprint for Action.

Recommendation: Launch an International Digital Democracy Initiative

The Commission recommends that the United States and ETC partner states launch an **International Digital Democracy Initiative (IDDI)**, a coordinated effort to align partner states' foreign assistance policies and programs to develop, promote, and fund the adoption of AI and associated technologies that comport with democratic values and ethical norms around openness, privacy, security, and reliability.²⁴¹ The IDDI will:

- Coordinate partner state approaches to adopting and governing digital technologies;
- Mobilize coalition effort to provide alternatives (through funding assistance, technology development, and private sector investment) to digital infrastructure and AI/ML-enabled technologies that are used for illiberal ends and to promote technologies that enhance democratic participation, human rights, and the rule of law; and

²⁴¹ The IDDI should mobilize financial resources and technical expertise as the DFI Alliance, a partnership between the U.S. International Development Finance Corporation and development finance institutions (DFIs) of 15 other OECD countries, ushered in response to Covid-19. See *Development Finance Institutions Join Forces to Respond to COVID-19 in Developing Countries*, U.S. International Development Finance Corporation (Apr. 6, 2020), <https://www.dfc.gov/media/press-releases/development-finance-institutions-join-forces-respond-covid-19-developing>.

- Facilitate adoption of secure, reliable, and trusted digital infrastructure, AI/ML-enabled technologies, and information and communications technology (ICT).²⁴²

Actions for the United States and Allies and Partners:

- **Coordinate national strategies that articulate involvement in IDDI.**
 - The United States and IDDI partners should take steps to coordinate the development of national strategies for IDDI involvement. By focusing on developing and investing in democratically aligned digital technologies and supporting digital development, infrastructure, and capacity-building projects, national strategies for IDDI should further the overarching goals of the ETC.
 - The Commission recommends that IDDI partners seek to align national strategies around common guidelines for investment strategies, critical technologies, policy guidance, and export promotion. A public diplomacy plan, and associated resources, should also be prominent within each national strategy given the importance of promoting a positive, unified message on the benefits and importance of IDDI.
- **Conduct an assessment of the global digital development landscape.**
 - IDDI partner states should convene with representatives from development agencies and international financial institutions (IFIs) to conduct an assessment of digital connectivity and the global digital development environment to guide IDDI activities.²⁴³
 - The Commission proposes that this assessment include:
 - A global risk evaluation of state-sponsored policies, financing and investment tools, surveillance technologies and other mechanisms that erode privacy and civil and human rights. This evaluation would inform IDDI priorities.
 - Identification of technologies or technological features to promote through IDDI activities, incorporating some or all of the following:
 - privacy protections, such as privacy-preserving ML, eyes-off ML, advanced encryption, and secure, multi-party computational models;²⁴⁴
 - protections against unwanted bias in data and inferences;

²⁴² The Global Infrastructure Hub has forecasted global telecommunications infrastructure investment need at \$8.9 trillion over the next approximately 20 years, with current trends falling short of the need by \$1 trillion. *Forecasting Infrastructure Investment Needs and Gaps*, Global Infrastructure Hub (2020), <https://outlook.gihub.org/>. The Alliance for Affordable Internet estimates it will cost \$428 billion and up to ten years to achieve universal connectivity to quality broadband internet. See Maiko Nakagaki, *\$428 Billion Investment Needed to Connect All of Humanity To the Internet by 2030*, Alliance for Affordable Internet (Sept. 17, 2020), <https://a4ai.org/428-billion-investment-needed-to-connect-all-of-humanity-to-the-internet-by-2030/>.

²⁴³ This could include bilateral development finance institutions (DFIs) in OECD member countries and multilateral DFIs, which are the private sector arms of multi-state IFIs. See *Development Finance Institutions and Private Sector Development*, OECD (last accessed Jan. 27, 2021), <https://www.oecd.org/development/development-finance-institutions-private-sector-development.htm>.

²⁴⁴ See the Chapter 7 Blueprint for Action; see also *Key Considerations for Responsible Development & Fielding of Artificial Intelligence*, NSCAI at 7-14 (July 2020), <https://www.nscai.gov/previous-reports/>.

- restrictions on the use of certain applications to prevent the potential infringement on civil and human rights;
 - data storage and access restrictions, to prevent access from third parties, multiple government agencies, and foreign governments;
 - secure, reliable AI tools and digital infrastructure;
 - tools and infrastructure to support “green” initiatives, including smart grids; and
 - tools for local populations to counter authoritarian, social control uses of AI.
 - Identification of best practices within IDDI members and existing initiatives that provide solid foundations to build upon and develop at scale. The IDDI should capitalize on the unique capabilities and resources of individual IDDI partner states.
- **Determine investment guidelines for technology development and digital development projects and support alignment through OECD.**
- Investment decisions into the development of specific technologies and funding of various digital development projects should be guided by the outcome of the assessment and agreed-upon digital development and AI use principles. These include:
 - *G20 Principles for Quality Infrastructure Investment*;²⁴⁵
 - *Principles for Digital Development*, used by USAID to guide digital foreign assistance efforts;²⁴⁶
 - *Criteria for Security and Trust in Telecommunications Networks and Services*, developed by the Department of State, the Center for Strategic and International Studies, and outside experts, and used by the Blue Dot Network;²⁴⁷
 - OECD’s *Recommendation on Digital Security of Critical Activities*²⁴⁸;
 - forthcoming *OECD Principles on Trusted Government Access to Data*;
 - *OECD Guidelines for Multinational Enterprises*;²⁴⁹ and
 - *UN Guiding Principles on Business and Human Rights*.²⁵⁰

²⁴⁵ *G20 Principles for Quality Infrastructure Investment*, (last accessed Jan. 4, 2021), https://www.mof.go.jp/english/international_policy/convention/g20/annex6_1.pdf.

²⁴⁶ “The Digital Principles were first created in consultation with organizations such as The Bill and Melinda Gates Foundation, the Swedish International Development Agency (SIDA), the UN’s Children’s Fund (UNICEF), UN Development Program (UNDP), the World Bank, and the U.S. Agency for International Development (USAID), and the World Health Organization (WHO).” See *Frequently Asked Questions*, *Principles for Digital Development* (last accessed Jan. 3, 2021), <https://digitalprinciples.org/about/>.

²⁴⁷ *Criteria for Security and Trust in Telecommunications Networks and Services*, CSIS Working Group on Trust and Security in 5G Networks, (May 2020), https://csis-website-prod.s3.amazonaws.com/s3fs-public/publication/200511_Lewis_5G_v3.pdf.

²⁴⁸ *Recommendation of the Council on Digital Security of Critical Activities*, OECD (Oct. 12, 2019), <https://legalinstruments.oecd.org/en/instruments/OECD-LEGAL-0456>.

²⁴⁹ *OECD Guidelines for Multinational Enterprises*, OECD (2011), <http://www.oecd.org/daf/inv/mne/48004323.pdf>.

²⁵⁰ *Guiding Principles on Business and Human Rights: Implementing the United Nation “Protect, Respect and Remedy” Framework*, United Nations Human Rights Office of the High Commissioner (2011), https://www.ohchr.org/Documents/Publications/GuidingPrinciplesBusinessHR_EN.pdf. To mark the 10th anniversary of the adoption of the UN Guiding Principles on Business & Human Rights (UNGPs), the UN will review existing gaps and develop a

- IDDI members should also work with the OECD to standardize AI and digital development assistance through the creation of a dedicated “Digital Development” purpose code.
 - A dedicated purpose code, monitored by the OECD’s Development Assistance Committee (DAC),²⁵¹ will demonstrate international resolve, facilitate coordination, enable the OECD and other entities to monitor funding in digital development activities, and consolidate data to inform IDDI strategic decision making.
- **Develop guidelines for the use of technologies within the IDDI.**
 - The risk assessment should lead to the development of guidelines for the use of AI/ML-enabled applications and surveillance technologies.
 - This effort should build on several foundational documents, including the OECD AI Principles²⁵² along with NSCAI’s *Key Considerations for Responsible Development & Fielding of Artificial Intelligence*,²⁵³ which provide operational guidance for the responsible and ethical development and use of AI in engineering practices, system performance, human-AI interaction, and accountability & governance.
- **Develop export promotion and control principles and coordinate adoption by each partner state.**
 - IDDI nations should establish priorities for export promotion and R&D activities to promote technologies that comport with shared democratic values and support free and open societies. These priorities may expand upon OECD guidelines and new U.S. Department of State guidelines on surveillance due diligence (see below on Promoting Democracy through Export Controls), to incentivize companies against transactions that could result in misuse of technology by government end-users.²⁵⁴
- **Expand public and private sector investments by exploring the creation of a joint investment fund and incentives for private investment.**
 - IDDI members should consider creating a joint investment fund—with a dedicated investment manager—to support IDDI projects. Such a fund could be

roadmap for the next decade. See *UN Guiding Principles: The Next Decade*, Business & Human Rights Resource Centre (last accessed Feb. 8, 2021), <https://www.business-humanrights.org/en/big-issues/un-guiding-principles-on-business-human-rights/un-guiding-principles-the-next-decade/>.

²⁵¹ *Development Finance Standards*, OECD (last accessed Jan. 27, 2020), <http://www.oecd.org/dac/financing-sustainable-development/development-finance-standards/>; *DAC and CRS Code Lists*, OECD (last accessed Dec. 28, 2020), <http://www.oecd.org/dac/financing-sustainable-development/development-finance-standards/dacandcrscodelists.htm>.

²⁵² *Recommendation of the Council on Artificial Intelligence*, OECD (May 21, 2019), <https://legalinstruments.oecd.org/en/instruments/OECD-LEGAL-0449>.

²⁵³ *Key Considerations for Responsible Development & Fielding of Artificial Intelligence*, NSCAI (July 2020), <https://www.nscai.gov/previous-reports/>.

²⁵⁴ See Chapter 14 of this report for additional details and recommendations pertaining to end-use and end-user export controls.

modeled on the Three Seas Initiative Investment Fund (3SIIF).

- As public sector investment is unlikely to achieve the scale necessary to realize IDDI goals and safeguard IDDI partner states' collective security,²⁵⁵ IDDI partners should seek to catalyze at least \$20 billion in private sector investment.
 - IDDI members could explore incentives for private sector investment in critical emerging technologies, particularly in the Indo-Pacific, Latin America, and other regions with strong growth potential. Policies to explore include tax incentives and subsidies, communication of IDDI priorities to the private sector, highlighting private sector investments and practices that advance IDDI goals, and increased taxes on profits made from strategic competitors' publicly-traded companies.²⁵⁶
- **Execute a coordinated strategic messaging and awareness campaign.**
 - The success of the IDDI will depend not only on coordinated investment and assistance activities, but also on the ability of IDDI members to effectively and strategically communicate the objectives to world leaders, international organizations, and the public.

Recommendation: Develop and Implement a Comprehensive U.S. National Plan to Support International Technology Efforts

The ISTS should include an integrated government-wide plan for coordinating the tools of U.S. foreign policy to advance the ETC, the IDDI, and standalone projects. This plan should leverage technical expertise, foreign assistance, development financing and investment, policy guidance, and export controls in support of three core goals:

1. Shaping international technical standards on AI and related technologies;
2. Implementing a coordinated U.S. policy for the IDDI; and
3. Promoting transparency and accountability through export controls.

Core Goal #1: Shape International Technical Standards

The United States and its allies should lead the way on international technical standardization for AI. U.S. government-led dialogue with U.S. industry, as well as democratic allies, can help overcome information asymmetries and clarify objectives for technical standards on AI that foster economic growth, protect consumers, and safeguard democratic values. Partnership and information-sharing between the U.S. government, industry, and academia is critical to ensure

²⁵⁵ For example, Hillhouse Capital, an Asia-focused private equity firm known for its early investments in Tencent and Baidu, grew from a "boutique hedge fund into a \$60 billion behemoth that's made prescient bets on stocks, private equity and venture capital." Hillhouse currently seeks to raise "what would be Asia's largest U.S. dollar-denominated fund targeting \$13 billion." See Michael McDonald & Lulu Yilun Chen, *Hillhouse Reloads After Building \$60 Billion Asia Juggernaut*, Bloomberg (Apr. 28, 2020), <https://www.bloomberg.com/news/articles/2020-04-27/yale-s-2-4-billion-profit-machine-hillhouse-ready-to-reload>; Kane Wu & Julie Zhu, *Exclusive: Hillhouse Targets Over \$3 billion for New Yuan-denominated Fund: Sources*, Reuters (Sept. 18, 2020), <https://www.reuters.com/article/us-hillhouse-fundraising-exclusive/exclusive-hillhouse-targets-over-3-billion-for-new-yuan-denominated-fund-sources-idUSKBN2690LK>.

²⁵⁶ See Chapters 11, 13, 14, and 16 of this report along with their associated Blueprints for Action for recommendations to strengthen public-private partnerships and private sector investments in the United States.

protection of national security concerns involving standards and the neutrality of international standards-setting bodies.²⁵⁷

Action for the President:

- **Issue an Executive Order to support international technical standardization.**
 - As detailed in NSCAI's *Interim Report and Third Quarter Recommendations*, the President should **issue an executive order**²⁵⁸ that would:
 - establish an interagency coordination task force for sharing threat information and identifying U.S. national security interests related to AI technical standards, and related standards such as international data science standards, to be led by NIST with membership from the Departments of State, Defense, Energy, Commerce, and Homeland Security, the Office of the Director of National Intelligence, and USAID;
 - direct the interagency task force to improve partnership and collaboration with industry and academia;
 - direct the interagency task force to consult with relevant congressional committees and develop a work plan with congressional appropriators on the necessary resources and full-time equivalents necessary to support U.S. leadership in international technical standardization;
 - direct federal agencies to resource and support focused research, test, and evaluation and regular and active participation by the United States Government in international standards-setting activities;
 - require the Director of NIST and the Standards Coordinator to encourage the private sector to create a Standardization Center to improve sharing of best practices and other information relevant to standards development, as well as support focused research coordination; and
 - establish a federal advisory committee with experts from the private sector and academia to provide strategic guidance to the interagency coordination task force on international technical standards.

Action for the Department of Commerce:

- **Coordinate technical standards development activities government-wide through NIST leadership of the interagency task force.**
 - The development of international standards for AI and emerging technology should be incorporated into the overarching ISTS. Within the U.S. government, this process must continue to be led by NIST with active participation of agencies in the coordination task force described above.

²⁵⁷ *Interim Report and Third Quarter Recommendations*, NSCAI at 205 (Oct. 2020), <https://www.nscai.gov/previous-reports/>.

²⁵⁸ This executive order would build upon Executive Order 13859. Donald J. Trump, *Executive Order on Maintaining American Leadership in Artificial Intelligence*, The White House (Feb. 11, 2019), <https://trumpwhitehouse.archives.gov/presidential-actions/executive-order-maintaining-american-leadership-artificial-intelligence/>; see also *Interim Report and Third Quarter Recommendations*, NSCAI at 207-12 (Oct. 2020), <https://www.nscai.gov/previous-reports/>.

- The Commission has proposed a comprehensive plan for NIST and other U.S. departments and agencies to ensure that the development of international technical standards receive greater attention and resourcing to ensure that U.S. national security interests, including the promotion of technologies that comport with democratic values, are advanced in standards development organizations.²⁵⁹
- NIST and other agencies should consider the Commission’s *Key Considerations for Responsible Development and Fielding of AI* in assessing positions on technical standards²⁶⁰
- **Convene a federal advisory committee to inform strategy on international standards.**
 - As noted above, the proposed executive order would create a federal advisory committee to provide the interagency task force with expert guidance to inform U.S. government strategy on international technical standards.
 - Members of the advisory committee should be drawn from the private sector and academia and should be selected by the interagency task force for their expertise in emerging technologies, geopolitical analysis, global economic trends, and similar fields.
 - The Commission envisions that this advisory committee, by focusing on strategic geopolitical issues around international technical standards, would serve a function not currently fulfilled by other advisory groups and the industry organizations that coordinate U.S. positions before international standards bodies.²⁶¹
 - The advisory committee should have a forward-looking mandate to contribute to U.S. government strategy on a range of emerging technologies—including technologies involved in genomics, digital currency, biopharma production, and others.
 - NIST and the Department of State should ensure that members receive appropriate clearances to facilitate exchanges of classified information necessary to the development of U.S. strategy.

Action for the Departments of Commerce and State:

- **NIST, with assistance from the Department of State, should coordinate technical standards development activities internationally.**
 - In addition, NIST, working closely with the Department of State—ideally, in the context of the ETC and the IDDI—must prioritize engagement with democratic

²⁵⁹ *Interim Report and Third Quarter Recommendations*, NSCAI at 206 (Oct. 2020), <https://www.nscai.gov/previous-reports/>

²⁶⁰ See the Chapter 15 Blueprint for Action Annex. For additional recommendations on how NIST can support qualified confidence in AI models and predicted outcomes see also Chapter 7 of this report and its associated Blueprint for Action.

²⁶¹ This includes the American National Standards Institute, the primary industry organization advocating for U.S. companies before international standards bodies and the International Digital Economy and Telecommunication Advisory Committee (IDET). See *Interim Report and Third Quarter Recommendations*, NSCAI at 208-9 (Oct. 2020); *About IDET*, U.S. Department of State (last accessed Feb. 11, 2021), <https://www.state.gov/international-digital-economy-and-telecommunication-advisory-committee/about-idet/>.

nations to align positions on standards critical to mutual security and defense and ensure those positions are reflected in deliberations of technical standards development organizations.

- The Department of State’s Regional Technology Officers can serve as conduits for this alignment (see below on Reorient U.S. Foreign Policy and the Department of State).

Actions for Congress:

- **Provide appropriate funding to NIST and other U.S. departments and agencies to support international technical standardization efforts.**
 - As the Commission has recommended,²⁶² Congress should provide funds sufficient to support at least 6 full-time equivalent personnel at NIST and at least one full-time equivalent each at the Departments of State, Defense, Homeland Security, and Energy, the Office of the Director of National Intelligence, USAID, and other agencies as may be appropriate. These personnel will support NIST’s AI Standards Coordinator, support focused research, and undertake other responsibilities necessary for technical standardization like participating in standards development organizations.
- **Provide appropriate funding, and grant-issuing authority, for the Department of State to ensure international leadership in developing technical standards.**
 - As the Commission has recommended,²⁶³ the Department of State must be properly resourced to fully engage in international forums, unions, and organizations focused on developing standards for AI, associated technologies, and data. Congress should provide a minimum of \$5 million to support these endeavors, particularly the recruitment and funding of U.S. academic scholars and researchers to participate in these international forums. This action may require the creation of a new foreign assistance fund and grant-issuing authority to a Department office.
- **Establish a grant program to enable small- and medium-sized U.S. AI companies to participate in international standardization efforts.**
 - As the Commission has recommended,²⁶⁴ Congress should authorize a grant program for small- and medium-sized U.S. AI companies to cover the high costs of engaging in international standardization efforts, including conducting relevant research, developing requisite skills and expertise, preparing standards proposals, and attending technical standards-setting meetings. Their input enables greater technological innovation, helps prevent potential high “switching costs” that may impede their growth, and facilitates solution development for standards that

²⁶² *Interim Report and Third Quarter Recommendations*, NSCAI at 206 (Oct. 2020), <https://www.nscai.gov/previous-reports/>.

²⁶³ *Id.*

²⁶⁴ *Id.*

- impede exporting by these small businesses.
- The Commission proposes that Congress appropriate an initial amount of \$1 million annually to fund grants issued by the Small Business Administration, in coordination with NIST.

Core Goal #2: Implement a Coordinated U.S. National Policy for the IDDI

A national policy for U.S. digital development efforts and involvement in IDDI will provide high-level strategic vision and coordination necessary to:

- Advance the interests of the United States and its allies and partners in the development and global adoption of AI/ML-enabled technologies and secure, trusted, and open digital ecosystems that promote values critical to free and open societies;
- Elevate—across U.S. departments and agencies—the prioritization of digital development necessary to advance U.S. interests and IDDI goals and reorient U.S. development efforts for a digital age; and
- Strengthen U.S. foreign policy through significant appropriations for digital development, increased resourcing and staffing, and expanded authorities for federal departments and agencies, particularly the Department of State, USAID, and DFC.

Actions for the ISTS Task Force:

- **Develop, as part of the ISTS, a U.S. national strategy for promoting digital technologies and supporting digital development, infrastructure, and capacity building.**
 - The ISTS should include a comprehensive and integrated approach to the foreign assistance and development financing tools of the U.S. government. This will enable coordinated U.S. participation in the broader IDDI effort and provide a roadmap to more effectively using U.S. government resources to support digital infrastructure development and democratic adoption of AI and emerging technology.
 - The strategy should also detail a strategic messaging and public awareness campaign to expose violations of international standards and democratic norms by authoritarian states.
- **Conduct an assessment of existing programs across the U.S. government, and associated funding, staffing, and authorities of ISTS Task Force entities.**
 - The ISTS Task Force should conduct an early assessment to guide development of this portion of the ISTS. The assessment should include:
 - An evaluation of current and recent interagency programs to identify best practices and priority countries as well as data governance frameworks and multilateral engagements on which more comprehensive efforts can be built.²⁶⁵

²⁶⁵ The Task Force should also evaluate efforts to promote targeted development priorities. For example, Power Africa is a “U.S. Government-led partnership, coordinated by USAID, that brings together the collective resources of over 150 public and private

- An evaluation of authorities, appropriations, and personnel necessary to achieve the objectives of the national strategy.²⁶⁶
- The ISTS Task Force should also consider addressing immediate needs for experts in emerging technology issues through innovative public-private fellowship rotation programs and intra-government details.
 - Personnel from CISA and the Defense Advanced Research Projects Agency (DARPA), for example, can help on immediate needs at the Department of State and USAID.

Action for USAID:

- **Prioritize implementation of the *Digital Strategy* and support urgent resourcing and organizational needs.**
 - The USAID *Digital Strategy*²⁶⁷ is an ambitious and necessary five-year plan for development and humanitarian assistance focused on promoting secure, trusted, and open digital ecosystems and the responsible use of AI technologies.
 - Implementation has lagged due to insufficient funding, inadequate staffing, and bureaucratic challenges. Currently, the *Digital Strategy* is administered by the Technology Division within the Innovation, Technology and Research Hub in the Bureau for Democracy, Development and Innovation (DDI).
 - The Commission recommends that the USAID Administrator continue efforts to transform the development paradigm by infusing a digital foundation across USAID portfolios.²⁶⁸ To this end, the Administrator should prioritize the *Digital Strategy* by (1) advocating for congressional appropriations to fund *Digital Strategy* programs (see *infra*), (2) augmenting development staff with experts in AI, 5G and connectivity, and cybersecurity, both at headquarters and in forward-deployed missions, (3) converting the Technology Division into a formal Center within DDI, and (4) prioritizing the inclusion of technology and digital across all development efforts.
 - Immediate staff augmentation can be accomplished by enhancing existing

sector partners to double access to electricity in sub-Saharan Africa.” See *Power Africa*, USAID (Nov. 30, 2020).

<https://www.usaid.gov/sites/default/files/documents/power-africa-fact-sheet-11-2020.pdf>.

²⁶⁶ This evaluation should include a review of the Defense Production Act (DPA) as a tool for DFC and potentially other agencies to promote the U.S. industrial base, as was done as part of the response to COVID-19. See *Defense Production Act (DPA)*, U.S. International Development Finance Corporation, (last accessed Jan. 4, 2021), <https://www.dfc.gov/dpa>.

²⁶⁷ The *Digital Strategy* includes several complementary efforts relating to connectivity, cybersecurity, digital finance, inclusion, and other areas, such as the Digital Connectivity and Cybersecurity Partnership, Digital Finance, Digital Inclusion, Geospatial Technology and Analytics, Development Informatics, Digital Agriculture, among others. Critical components of the Digital Strategy also include catalytic funding provided to missions (Digital Ecosystem Fund) and conducting Digital Ecosystem Country Assessments (DECAs). See *USAID Digital Strategy 2020-2024*, USAID, (Jun. 2020), <https://www.usaid.gov/usaid-digital-strategy>. USAID has also published resources which are reflective of the Digital Strategy and outline democratic principles in the deployment of those technologies. See e.g., Amy Paul, et al., *Reflecting the Past, Shaping the Future: Making AI Work for International Development*, USAID (May 2, 2019), <https://www.usaid.gov/sites/default/files/documents/15396/AI-ML-in-Development.pdf>; *Artificial Intelligence in Global Health: Defining a Collective Path Forward*, USAID (2020), https://www.usaid.gov/sites/default/files/documents/1864/AI-in-Global-Health_webFinal_508.pdf.

²⁶⁸ For example, USAID may want to explore the potential for all its programs to include a minimum threshold of digital programming (e.g., 10% of programmatic efforts include an element of digital development) as a key element of supporting nations on their journey to self-reliance.

implementing partnerships with the private and non-profit sectors, through direct hires, fellowship programs for researchers, and details from other federal agencies.

- Longer-term staffing needs would benefit from creating a foreign service backstop from the recommended Center focused on digital expertise to strengthen USAID’s ability to identify needs, assess risks, and execute on programmatic activities around digital development.

Action for DFC:

- **Expand formal relationships with international partners and private foundations to expand the scope of DFC investments and connectivity projects through blended financing arrangements.**
 - DFC’s *Roadmap for Impact* is a five-year effort to catalyze \$75 billion—\$25 billion by DFC, \$50 billion from the private sector—and provide technical expertise and support to optimize development impact.²⁶⁹ The *Roadmap for Impact* proposes to “elevate innovation and technology across at least 50 percent of the DFC portfolio” and devote \$5 billion for digital infrastructure projects and increasing internet access.²⁷⁰
 - Current authorities limit DFC’s ability to invest in higher risk transactions, which presents challenges for scaling digital infrastructure projects, particularly in developing countries.
 - DFC investments are scored under the Federal Credit Reform Act, and DFC has limited budget authority for subsidy for equity financing (\$150 million) and debt financing and technical assistance (\$30 million).²⁷¹
 - DFC cannot provide concessionary lending, unlike China²⁷² and peer agencies, such as the Japan Bank for International Cooperation and European Investment Bank, as well as the World Bank.²⁷³
 - DFC should deepen its relationships with existing and new international partners to expand the scope of its financing and equity investments in the digital development space.²⁷⁴

²⁶⁹ *Roadmap for Impact*, DFC (last accessed Nov. 25, 2020), <https://www.dfc.gov/roadmap-for-impact> [hereinafter DFC Roadmap for Impact].

²⁷⁰ DFC Roadmap for Impact at 6.

²⁷¹ DFC Roadmap for Impact at 57; *Congressional Budget Justification: Fiscal Year 2021*, DFC (last accessed Nov. 25, 2020), https://www.dfc.gov/sites/default/files/media/documents/FY2021_DFC_CBJ-Final-04222020.pdf [hereinafter DFC FY2021 Budget].

²⁷² The China Development Bank and China Exim Bank provide concessionary loans, including, for example, a 40-year concessionary loan to Indonesia to fund its US \$5.29 B high-speed railway. The loan provided a 10-year grace period, no guarantees by Indonesia, and local content guarantees. See *China’s Belt and Road Initiative in the Global Trade, Investment, and Finance Landscape*, OECD at 18 (2018), <https://www.oecd.org/finance/Chinas-Belt-and-Road-Initiative-in-the-global-trade-investment-and-finance-landscape.pdf>.

²⁷³ *Policy Update*, Donor Tracker (July 23, 2020), <https://donortracker.org/policy-updates/european-investment-bank-provide-us84-million-concessional-loan-senegal-support>; *Japanese Concessional ODA Loans*, United Nations (last accessed Feb. 2, 2021), <https://www.un.org/ldcportal/japanese-concessional-oda-loans/>; *Understanding China’s Belt and Road Infrastructure Projects in Africa*, Brookings (Sept. 2019), https://www.brookings.edu/wp-content/uploads/2019/09/FP_20190930_china_bri_dollar.pdf.

²⁷⁴ DFC has formal relationships with international partners such as Japan and Australia (Japan Bank for International Cooperation, Nippon Export Investment Insurance, Australia Infrastructure Financing Facility), the African Development Bank,

- Similarly, DFC should expand partnerships with a broader range of non-governmental entities to leverage its own appropriations through blended financing arrangements that enable higher risk investments.²⁷⁵
- This may include creating a digital technology fund²⁷⁶ that invests in developing secure, trusted digital infrastructure, AI/ML-enabled technologies, and ICT with technical features that comport with democratic values and ethical norms around openness, privacy, security, and reliability.

Actions for Congress:

- **Create an allocated Emerging Technology Fund for foreign operations and related programs of USAID and the Department of State.**
 - The underfunding of U.S. digital foreign assistance and financing programs is exacerbated by competition with other funding priorities and lack of a flexible allocated budget.
 - Congress should authorize an allocated budget account, the Emerging Technology Fund, to facilitate holistic planning of digital foreign assistance, digital development projects, emerging technology programs, and other ISTS activities.
 - The Commission proposes that the allocated account include the requests for additional, targeted appropriations for USAID and the Department of State.
 - Existing digital-related programs could also be consolidated into the Emerging Technology Fund.
- **Appropriate \$200 million annually to implement the USAID *Digital Strategy*.**
 - The Commission recommends Congress appropriate a minimum of \$200 million annually to support implementation of the USAID *Digital Strategy* by the Technology Division within DDI, with required funding likely multiples higher. The funds should support programmatic activities as well as critical hiring needs.

and the Inter-American Development Bank. See Testimony by Adam S. Boehler, CEO, U.S. International Development Finance Corporation before the House Appropriations Subcommittee on State and Foreign Operations, and Related Programs (Mar. 4, 2020), <https://www.dfc.gov/testimony-DFC-HAP-03042020>.

²⁷⁵ Blended finance, according to the OECD, “is the strategic use of development finance for the mobilisation of additional finance towards sustainable development in developing countries.” Blended concessional finance includes the “use of relatively small amounts of concessional donor funds to mitigate specific investment risks and help rebalance risk-reward profiles of pioneering investments that are unable to proceed on strictly commercial terms.” See *Blended Finance*, OECD (last accessed Dec. 28, 2020), <https://www.oecd.org/dac/financing-sustainable-development/blended-finance-principles/>; *Blended Concessional Finance*, International Finance Corporation of the World Bank Group (last accessed Dec. 28, 2020), https://www.ifc.org/wps/wcm/connect/topics_ext_content/ifc_external_corporate_site/bf; see also *Blended Finance*, Convergence (last accessed Dec. 28, 2020), <https://www.convergencefinance.com/blended-finance>.

²⁷⁶ This investment fund could be modelled after the \$100 million Women’s World Banking Asset Management Fund, which received \$25 million from DFC and \$600,000 from USAID. Additionally, DFC put out a call for proposals for fund managers investing in 5G related companies operated in DFC-eligible emerging market countries in order to invest in open and secure ICT. See *First-of-Its-Kind U.S. Government Blended Finance Fund to Empower Women in Developing Markets*, DFC (Jun. 4, 2019), <https://www.dfc.gov/media/opic-press-releases/first-its-kind-us-government-blended-finance-fund-empower-women>; *Information and Communication Technology Call for Proposals*, DFC (Mar. 2020), https://www.dfc.gov/sites/default/files/media/documents/IFD_5G_CFP_032020.pdf.

- This amount builds on USAID’s FY 2021 request for \$82 million,²⁷⁷ which includes support for the Digital Ecosystem Fund,²⁷⁸ staff augmentation, and programmatic activities.
- **Appropriate \$300 million annually for the Department of State’s emerging technology programs.**
 - The Commission recommends Congress appropriate a minimum of \$300 million annually to support the Department of State’s emerging technology programs and administrative needs and to build what is currently a small cross-Department group of officials with expertise in emerging technology issues.
 - These funds should include the immediate request for supplemental appropriations, described later in this Blueprint for Action, for \$70 million to address urgent diplomatic efforts, programs, and foreign operations in AI, emerging technologies, and data.
 - Additional funding would support foreign assistance activities around emerging tech and digital infrastructure, to include planning, assessments, and provision of assistance. Funds would support targeted, digital programs in several areas, including Department of State programs involving the rule of law (INL), democracy and human rights (DRL), security cooperation (AVC/PM/ISN), and technical assistance (EB, STAS, others).
- **Provide DFC with sufficient appropriations to strengthen development finance as a tool for achieving national objectives.**
 - To improve the ability of the U.S. government to leverage the tools of development finance and equity investments to further the ISTS mission, Congress should provide DFC with \$1 billion in flexible, programmatic funding to support digital development projects.²⁷⁹
- **Increase DFC’s capacity for blended development financing through interagency partnerships.**
 - Congress has restricted the appropriations available for USAID, MCC, and the Department of State to partner with DFC in blended transactions.²⁸⁰ USAID and

²⁷⁷ The \$82 million request was part of the larger \$640.1 million requested to support DDI’s efforts. See *Congressional Budget Justification: Foreign Operations: Appendix 2: FY 2021*, U.S. Department of State at 223 (2020), <https://www.state.gov/wp-content/uploads/2021/01/FY21-CBJ-Appendix-2-FINAL-508-Version.pdf>.

²⁷⁸ The Digital Ecosystem Fund “equips the Agency’s Operating Units with catalytic financing to design and implement activities that foster open, inclusive, and secure digital ecosystems. The DEF supports two types of interventions: 1) Emergent opportunities to harness or shape the digital ecosystem in any sector; 2) Strategic initiatives to strengthen or improve the digital ecosystem.” See *Digital Ecosystem Fund: 2020 Activities*, USAID (Dec. 22, 2020), <https://www.usaid.gov/digital-development/DEF2020>.

²⁷⁹ DFC’s FY 2021 budget request sought \$700 million in such funds. See DFC FY2021 Budget at 1.

²⁸⁰ The U.S. government announced a first-of-its-kind blended finance fund in June 2019. USAID provided \$600,000 in funding and technical assistance and DFC’s predecessor invested \$25 million to support private capital investments in the \$100 million Women’s World Banking Asset Management Fund. See *First-of-Its-Kind U.S. Government Blended Finance Fund to Empower*

the Department of State are limited to transferring \$50 million overall—spread across all projects, not limited to digital.²⁸¹

- As DFC's role in digital development investments increases, the need for funds from the Department of State, USAID, and MCC will also increase, requiring an equivalent increase in funding to support USAID, State, and MCC digital and AI-related efforts that may be tabled to enable a transfer of funds to DFC.²⁸²
- The Commission proposes that Congress appropriate a total of **\$200 million to the Department of State, USAID, and MCC** to be used for DFC investment programs.

- **Appropriate funds support critical personnel needs at DFC.**

- Congress should appropriate funds sufficient for DFC to increase its forward-deployed personnel, located in regions in which DFC invests.
 - Currently, 98% of DFC staff is based in Washington, DC. This puts DFC at a disadvantage vis-a-vis foreign development finance institutions (DFIs). By comparison, DFC estimates that peer DFIs have roughly four times the number of staff and base them predominantly in low- and lower middle-income countries.²⁸³

Core Goal #3: Promote Transparency and Accountability through Export Controls

ISTS objectives will be furthered by the U.S. government's ability to harness the power of the U.S. private sector. A critical tool for achieving this involves incentivizing the export of technologies that align with democratic values.

Action for the Departments of Commerce and State:

- **Develop end-user licensing policies and export controls as part of the ISTS.**
 - The Department of Commerce, through the Bureau of Industry and Security (BIS), should use targeted end-use controls and human rights due diligence reporting requirements to prevent and deter U.S. firms from enabling problematic government end uses of AI and associated technologies.²⁸⁴
 - BIS should build on its 2020 request for public comments on ways to strengthen controls and monitoring of advanced surveillance systems—this area could be explored to prevent the use of compute-intensive technologies for human rights abuses while furthering the promotion of democratic-aligned technology. Regulations issued in October 2020

Women in Developing Markets, DFC (June 4, 2019), <https://www.dfc.gov/media/opic-press-releases/first-its-kind-us-government-blended-finance-fund-empower-women>; Vince Chadwick, *USAID, OPIC Team Up on Women's Finance in 'Preview' of New DFI Era*, Devex (June 5, 2019), <https://www.devex.com/news/usaaid-opic-team-up-on-women-s-finance-in-preview-of-new-dfi-era-95050>.

²⁸¹ See, e.g., DFC Roadmap for Impact at 57.

²⁸² DFC FY2021 Budget; DFC Roadmap for Impact.

²⁸³ DFC Roadmap for Impact at 56.

²⁸⁴ See Chapter 14 of this report for recommendations regarding specific end-use controls on high-end AI chips.

provide BIS with discretion to deny export licenses for products that could be used to violate or abuse human rights.²⁸⁵

- Coordinated with the ISTS Task Force, these stronger export control rules can promote the ethical and responsible use of AI among U.S. firms, set standards for global industry, and counter abuses of human and civil rights.
- The Department of State, through the Bureaus of Democracy, Human Rights and Labor (DRL), International Security and Nonproliferation (ISN), and Political-Military Affairs (PM), should expand upon its recently issued framework to guide businesses in assessing risks of human rights abuses when exporting surveillance equipment,²⁸⁶ while bolstering the promotion of democratic values.
- In coordination with the Department of Commerce, the Department of State should expand data collection and analysis of human rights abuses associated with emerging technologies and authoritarian digital practices.²⁸⁷

Recommendation: Enhance the United States' Position as an International Emerging Technology Research Hub

The third component of the ISTS is to enhance the role of the United States as an international emerging technology research hub. The goals are to:

- Facilitate U.S. government contributions to collaborative initiatives and technical standards, such as Global Partnership on AI (GPAI)²⁸⁸ and digital projects of the OECD;
- Strengthen the talent of the United States, allies, and partners by investing in people through workforce development, mentorship, and exchange programs facilitated through the recommended Multilateral AI Research Institute (MAIRI);
- Foster collaborative research relationships and pool research resources for the development of technologies (particularly in civilian applications) that comport with democratic values and address gaps in commercial R&D, including joint research in privacy-enhancing technologies; and

²⁸⁵ 85 Fed. Reg. 43532, *Advanced Surveillance Systems and Other Items of Human Rights Concern*, U.S. Department of Commerce: Bureau of Industry and Security (July 17, 2020), <https://www.federalregister.gov/documents/2020/07/17/2020-15416/advanced-surveillance-systems-and-other-items-of-human-rights-concern>; 85 Fed. Reg. 63007, *Amendment to Licensing Policy for Items Controlled for Crime Control Reasons*, U.S. Department of Commerce: Bureau of Industry and Security (Oct. 6, 2020), <https://www.federalregister.gov/documents/2020/10/06/2020-21815/amendment-to-licensing-policy-for-items-controlled-for-crime-control-reasons>.

²⁸⁶ *Guidance on Implementing the UN Guiding Principles for Transactions Linked to Foreign Government End-Users for Products or Services with Surveillance Capabilities*, U.S. Department of State (last accessed Jan. 4, 2021), <https://www.state.gov/wp-content/uploads/2020/10/DRL-Industry-Guidance-Project-FINAL-1-pager-508-1.pdf>.

²⁸⁷ Kara Frederick, *Democracy by Design: An Affirmative Response to the Illiberal Use of Technology for 2021*, Center for a New American Security (Dec. 15, 2020), <https://www.cnas.org/publications/reports/democracy-by-design>; Dahlia Peterson, *Designing Alternatives to China's Repressive Surveillance State*, Center for Security and Emerging Technology (Oct. 2020), <https://cset.georgetown.edu/wp-content/uploads/CSET-Designing-Alternatives-to-Chinas-Surveillance-State.pdf>.

²⁸⁸ GPAI was launched in June 2020 to advance “responsible and human-centric” AI consistent with human rights, fundamental freedoms, democratic values, innovation and economic growth. Current members include Australia, Brazil, Canada, the European Union, France, Germany, India, Italy, Japan, Mexico, the Netherlands, New Zealand, Poland, Singapore, Slovenia, South Korea, Spain, the United Kingdom, and the United States, with the OECD and UNESCO as Permanent Observers. See *UNESCO Joins Global Partnership on Artificial Intelligence as Observer*, UNESCO (Dec. 10, 2020), <https://en.unesco.org/news/unesco-joins-global-partnership-artificial-intelligence-observer>.

- Enable the U.S. and allies to overcome current regulatory challenges currently inhibiting collaboration, particularly in Europe, such as data sharing restrictions and liability agreements.

Component #1: Support International Digital and AI R&D

International efforts, like the GPAI and the OECD's AI and digital initiatives, are critical forums for facilitating alignment among like-minded countries on advancing the responsible and human-centric development and use of AI. Research undertaken by the National AI Research Institutes—run by the NSF and other U.S. agencies—and by other programs across Federal departments and agencies is an incredible resource that should support these key international efforts and advance AI and digital goals of the U.S. and like-minded partners.

Actions for the Department of State, OSTP, and NSF:

- **Formalize a center of expertise relationship with the Global Partnership on Artificial Intelligence (GPAI).**
 - NSF should evaluate candidates to serve as a U.S. center of expertise for GPAI. NSF should submit a recommendation to the Director of OSTP to guide negotiations with GPAI.
 - NSF should consider candidates from among its AI-related awardees, including the National AI Research Institutes or by establishing a coordination hub of all Institutes. NSF should also propose methods for leveraging other U.S. science and research agencies, such as the Department of Energy and NIST, to support the center of expertise.
 - In coordination with the Department of State and OSTP, NSF should negotiate a memorandum of understanding between NSF and GPAI to formalize the center's support of GPAI working groups.²⁸⁹
- **Increase support to the OECD's AI and digital efforts.**
 - The U.S. government should expand its collaboration with the OECD's AI initiatives, including those of the Directorate for Science, Technology and Innovation and the AI Policy Observatory.²⁹⁰ The Commission proposes an expanded relationship in three ways.

²⁸⁹ GPAI's five working groups (responsible AI, data governance, innovation and commercialization, the future of work, and pandemic response) are supported by research undertaken by two centres of expertise: the Paris-based National Institute for Research in Digital Science and Technology (INRIA) and the Montreal-based International Centre of Expertise in Montreal for the Advancement of Artificial Intelligence (ICEMAI). See *The Global Partnership on Artificial Intelligence Officially Launched*, Montreal International (June 15, 2020), <https://www.montrealinternational.com/en/news/the-global-partnership-on-artificial-intelligence-officially-launched/>; *Launch of the Global Partnership on Artificial Intelligence by 15 Founding Members*, French Ministry for Europe and Foreign Affairs (June 15, 2020), <https://www.diplomatie.gouv.fr/en/french-foreign-policy/digital-diplomacy/news/article/launch-of-the-global-partnership-on-artificial-intelligence-by-15-founding>.

²⁹⁰ The OECD's work through the Directorate for Science, Technology and Innovation and the AI Policy Observatory is supported by partnerships with governments and research entities, like the German AI Observatory's support of the OECD's effort on AI's impact on the labor market. See *Work, Innovation, Productivity and Skills programme: Overview*, OECD.AI (last accessed Feb. 1, 2021), <https://oecd.ai/work-innovation-productivity-skills>.

- First, NSF should explore methods to support OECD’s “Going Digital” program²⁹¹ to promote data sharing among partner nations.
 - Input should include pilots on cross-border data flow measurement, taxonomies to compare countries’ data initiatives, or data governance policies.
- Second, the Department of State, OSTP, and NSF should look for opportunities to align with allies and partners through the OECD on data guidelines, in particular by promoting value-based best practices for collecting (e.g., with consent and contributor controls), documenting (e.g., to support responsible use and quality), using data in R&D (e.g., with transparency), and then making data used in published research available to the broader research community (e.g., for reproducibility).
- Third, OSTP should work with the OECD to formalize a “network of research nodes” to coordinate AI and digital-related efforts and R&D centers worldwide. Policymakers and researchers would greatly benefit from a global information platform that enables easier understanding of the various AI and related initiatives and ongoing research efforts.

Action for Congress:

- **Provide administrative funding to support U.S. research contributions to GPAI.**
 - The centers of expertise that support GPAI also provide administrative and secretariat-like assistance (e.g., planning of GPAI plenaries). Congress should therefore provide additional resourcing to NSF to support the center’s development, administrative staff, and resourcing to leverage research from NSF’s AI portfolio, including the National AI Research Institutes, and from other U.S. departments and agencies as needed.
 - The Commission recommends a minimum of \$3 million over a three-year period.

Component #2: Establish the Multilateral AI Research Institute (MAIRI)

The **Multilateral AI Research Institute (MAIRI)** will provide a model for equitable, multilateral research, facilitate AI R&D that builds on like-minded countries’ strengths, and develop the next generation global AI workforce. With a physical center located in the United States with a virtual presence, MAIRI will enable collaborative research among key allies and partners and contribute to a broader effort—reflected in the Emerging Technology Coalition and IDDI—to preserve free and open societies, win the global technology competition, and foster AI innovation in a manner that comports with democratic values. Ultimately, to further these objectives, MAIRI should seek to facilitate a federated network of research institutes across the globe and with national labs and university hubs.

Actions for the NSF:

²⁹¹ *Going Digital*, OECD (last accessed Feb. 2, 2021), <http://www.oecd.org/going-digital/project/>.

- **Establish MAIRI in the US and support involvement of U.S. researchers in MAIRI.**

- NSF should establish MAIRI, modeled on the Banff International Research Station.²⁹² MAIRI should have a physical center in the United States, as well as a virtual presence. NSF should provide MAIRI with all staff necessary to ensure its success.
 - Although NSF does not require further authorities to establish MAIRI, legislation could facilitate this process (see actions for Congress).
- MAIRI should be designed with sufficient flexibility to enable involvement by researchers from industry, academia, and research institutions and philanthropies on a project-by-project basis; other U.S. departments and agencies, like the Department of Energy, may be critical for leveraging the entire US R&D ecosystem.
- NSF programs through the Office of International Science and Engineering (OISE) can support MAIRI by facilitating involvement of U.S. researchers.
 - *AccelNet*²⁹³ can fund the travel, virtual networking and other activities necessary to support research projects between research networks.
 - *MULTIPLIER*²⁹⁴ may support subject matter experts' travel to identify collaboration opportunities with founding members or with countries that are considering joining MAIRI.

- **Identify key allies and partners to be MAIRI founding members.**

- NSF, in close coordination with the Department of State, should identify and negotiate involvement of founding members.
- The Commission recommends that founding members include Australia, Canada, France, Germany, Italy, Japan, New Zealand, South Korea, and the United Kingdom.
 - These countries have existing agreements and collaborative relationships with the United States that could be more readily leveraged to develop the center. They also have extensive research capabilities and share values and interests with the United States.
- Expansion to include additional allies and partners should be prioritized; for example:
 - European Union involvement should be a priority; however, the EU's inclusion in MAIRI will depend on the ability to overcome disagreements

²⁹² Banff International Research Station (last accessed Jan. 4, 2021), <https://www.birs.ca/>.

²⁹³ AccelNet accelerates network to network collaborations by funding the connection (travel, virtual networking, workshops) between international research networks. NSF only funds the US portion and expects international partners to fund their part of the collaboration. In addition to funding connections between existing networks, AccelNet will fund efforts to create and foster nascent networks. See *Accelerating Research through International Network-to-Network Collaborations (AccelNet)*, NSF (Sept. 21, 2020), https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=505584&org=OISE&from=home.

²⁹⁴ MULTIPLIER sends subject matter experts to international areas of interest to assess capabilities and gather information for potential NSF joint projects. This new program has already been promising—NSF sent a multidisciplinary team to the Czech Republic and was astounded at their capabilities. NSF is now exploring bilateral collaboration. See *NSF MULTIPLIER - MULTIPLYing Impact Leveraging International Expertise in Research Missions*, NSF (last accessed Dec. 28, 2020), <https://www.nsf.gov/od/oise/multiplier.jsp>; NSCAI staff discussions with NSF staff (Nov. 14, 2020).

between the EU and United States over governing law, liability, funding, data sharing, and intellectual property.

- Involvement by India should also be prioritized as MAIRI develops, building on the Commission’s recommended **U.S.-India Strategic Tech Alliance**.

- **Develop research integrity principles with MAIRI’s founding members.**

- Founding members would agree to a jointly determined *Principles for Multilateral AI Research*, which would be founded on the importance of research integrity. Principles may include the need for transparency, particularly in disclosing funding and international connections; the necessity for open data and data sharing; the development of risk-benefit frameworks; and the use of merit-based competition reviews of research proposals.
- Members would also receive training on security risks and agree to use trusted infrastructure as part of founding principles (see recommended appropriations in actions for Congress).
- The agreement will also detail the terms for handling intellectual property, sharing data, governing law and liability, and funding.

- **Develop concrete research agenda with MAIRI’s founding members.**

- Once founding members have agreed to the *Principles*, they will determine focus areas and initiatives. Countries will fund the involvement of their researchers in joint projects. Joint research projects will occur through virtual spaces as well as at partner entities like research institutions and universities that receive funding from MAIRI. The facilities of other participating departments and agencies may also be used.²⁹⁵
- *Research Priorities*: Projects should be chosen to leverage members’ comparative advantages, enabling participants to learn from partner researchers. Examples of R&D priorities are provided in the Emerging Technology Coalition Annex to this Blueprint for Action. Priorities should include:
 - Building shared, secure compute resources (including high performance, cloud, and quantum computing),²⁹⁶ including joint benchmarking projects and data sharing, pooling, and storing initiatives founded on commonly agreed upon principles that ensure trust, privacy, and security.
 - Privacy-preserving AI/ML technologies, including technologies like federated learning and on-device prediction that enable remote execution, encrypted computation through multi-party computation and homomorphic encryption, and differential privacy.

²⁹⁵ For example, the Department of Energy’s national laboratories may be used to sponsor research with the recommended dedicated funding.

²⁹⁶ The shared research resource can help prevent bottlenecks due to limited compute resources. This effort may also be, if appropriate, part of an expansion of the National AI Research Resource delineated in Chapter 9 of this report.

- Developing smart city technologies, aligned with democratic values, that promote sustainability as well as norms that should guide standards development at bodies like the ITU and technical standards bodies.
- **Coordinate with MAIRI founding members on funding, international agreements, and governance structures.**
 - Although the United States should fund the initial start-up costs, including acquisition of MAIRI’s physical center, staff, and virtual research/networking infrastructure (see recommendations to Congress below) each member should thereafter provide proportionate financial contributions to MAIRI’s R&D and to the participation of their researchers in MAIRI-sponsored workshops and conferences²⁹⁷ modeled on the approach used by the Banff International Research Station.²⁹⁸
 - For ongoing operations, MAIRI should explore the potential to develop an endowment, modelled on the three US-Israeli binational funds. This approach would facilitate the use of philanthropic donations to support MAIRI.
 - Umbrella international AI/S&T agreements—negotiated with NSF, MAIRI members, and U.S. agencies—will facilitate cooperation among allies and partners beyond MAIRI.
 - Once established, MAIRI may support GPAI and other international efforts. MAIRI should also pursue research agreements with other centers of excellence and research centers focused on AI research and development to create a federated network of research institutes throughout the globe.
 - MAIRI members should also determine how they will determine expanding MAIRI’s membership, particularly to the European Union and India.

Action for Other U.S. Departments and Agencies:

- **Support the establishment of MAIRI and its R&D.**
 - NSF will be the U.S. anchor partner for MAIRI. Its success requires leveraging the entire U.S. R&D ecosystem and government research entities.²⁹⁹ The

²⁹⁷ NSCAI recommends each member dedicate funding to support research efforts. However, MAIRI will also serve as a location for research to gather for dialogues, workshops, and mentorships. Based on similar international research institutes, MAIRI members should consider providing the equivalent of \$100-\$250K per year to cover the travel, accommodations, and per diem of around 80 researchers to MAIRI to facilitate communications and interactions between researchers.

²⁹⁸ In 2017, the government of Alberta (Canada), Canadian Natural Science and Engineering Research Council, U.S. National Science Foundation, and Mexico’s Consejo Nacional de Ciencia y Tecnología invested \$12.5 million over the next five years. See *Research Station Gets \$12.5M to Bring Scientists and Mathematicians to Banff*, CBC News (Feb. 10, 2017), <https://www.cbc.ca/news/canada/calgary/banff-international-research-station-math-science-funding-1.3977703>. For the 2012-2017 period, BIRS received \$10.3 million, of which \$3.68 million was from NSF. For the 2006 - 2011 period, BIRS received \$9.3 million, \$3.1 million of which from NSF. See *Organization: Banff International Research Station*, Research Money (last accessed Jan. 4, 2021), <https://researchmoneyinc.com/organization/banff-international-research-station/>.

²⁹⁹ The National AI Research Institutes provide an important example of the power of leveraging R&D cooperation across the U.S. interagency. The new NSF and DOE centers for quantum information science are also a powerful example of the benefits of dedicated resourcing and prioritization across two U.S. government research entities. See Andrea Peterson, *NSF and DOE Support Research Priorities with Spate of New Center Awards*, American Institute of Physics (Sept. 16, 2020), <https://www.aip.org/fyi/2020/nsf-and-doe-support-research-priorities-spate-new-center-awards>.

Departments of Energy and State as well as NIST, in particular, should be critical partners.

- The Department of Energy should leverage its national labs, history of working with industry, immense technical capabilities and experience on applied research, and expertise in high-performance computing (HPC) and quantum computing.
- The Department of State should provide foreign policy expertise and diplomacy, including by assigning a dedicated Foreign Service Officer, to support the creation of MAIRI as well as identification of beneficial projects.
- Other federal entities, including the National Institutes of Health, the National Oceanic and Atmospheric Administration (NOAA), and the Department of Health and Human Services, will be critical for technical expertise and collaboration on targeted research projects.

Actions for Congress:

- **Pass legislation to formally authorize MAIRI.**
 - Although not required for MAIRI's establishment, Congress should pass legislation that formally authorizes the creation of MAIRI and clarifies the authorities of other executive agencies to award funding to MAIRI. This will serve as a signal of the importance of international AI collaboration and ensure NSF and partner agencies have sufficiently robust authorities to achieve its objectives.
 - Legislation should also specifically authorize and direct NSF, in coordination with the Department of State, to create a trusted learning cloud and associated compute capacity to facilitate international collaborative research.
 - The trusted learning cloud would enable access to needed resources, compute, and data for shared innovation and development of data sharing standards that could be a model for a larger international data sharing framework.
- **Support the establishment of MAIRI through appropriate funding to NSF and other critical agencies.**
 - The Commission recommends Congress appropriate a minimum of \$60,750,000 for a five-year period, which will be supplemented by contributions from international partners.
 - The proposed appropriations are as follows:
 - \$10 million per year for five years to NSF and other critical agencies (such as the Departments of Energy and State) for research initiatives.
 - \$2 million per year for five years to NSF for establishing and maintaining the physical center located in the United States, its associated infrastructure, and administrative operations.
 - \$150,000 per year for five years to NSF to support U.S. researchers' travel and associated expenses to partake in MAIRI's workshops, conferences, and other events at the physical center.

- The Commission recommends Congress appropriate \$11.25 million per year for research initiatives dedicated to creating a trusted learning cloud and associated compute capacity to facilitate international collaborative research.
- **Create an endowment for MAIRI to support ongoing funding.**
 - MAIRI may wish to develop an endowment fund similar to the U.S.-Israeli binational foundations. If pursued, Congress should authorize this endowment fund and support an initial U.S. investment. Additional appropriations would be required to support a MAIRI endowment fund secretariat.

Component #3: Expand Talent Exchanges

The United States must attract talent to collaborative research endeavors at both the National AI Research Institutes and MAIRI. Sustained, strong collaboration between MAIRI partners is critical to ensure responsible, secure, human-centric AI prevails over authoritarian AI. Shoulder-to-shoulder research and talent exchanges are invaluable, enabling researchers to build relationships, learn from each other, exchange ideas, and spark future collaborations.

Action for the Department of State:

- **Leverage O and J visa programs to attract skilled researchers to support MAIRI and international talent exchange programs.**
 - The Department of State, in coordination with the Department of Homeland Security, should leverage the O and J visa programs to facilitate foreign researchers to travel to the United States to work collaboratively with researchers from the United States and other nations.³⁰⁰ There are no statutory caps on the number of visas issued under these programs.³⁰¹

Recommendation: Reorient U.S. Foreign Policy and the Department of State for Great Power Competition in the Digital Age

In the near term, it is imperative to establish a Department of State focal point for emerging technology policy and expertise and resourcing through steps the Commission proposes below. In the longer term, the United States must fundamentally reorganize the structure, focus, and culture of the Department of State to advance American interests at the intersection of democracy, technology, security, commerce, and human rights.³⁰² Without high-level support in

³⁰⁰ For more information, see the Chapter 10 Blueprint for Action.

³⁰¹ J-1 visas are used by academic employers like universities and research institutions to sponsor foreign-born academics, interns, trainees, and researchers to work for several months to five years in the United States. J-1 visa holders are not allowed to renew their visa and must wait one to two years before they can apply for a different immigration status. O-1 visas are for individuals who can provide extensive evidence that they have “extraordinary ability in the sciences, arts, education, business, or athletics.” These visas last for up to three years with indefinite renewals but have been used minimally to attract experts in science and technology due to restrictive policy guidance. For a discussion of immigration and visa programs to attract scientists and researchers to the United States, see generally Zachary Arnold, et al., *Immigration Policy and the U.S. AI Sector*, CSET (Sept. 2019), <https://cset.georgetown.edu/research/immigration-policy-and-the-u-s-ai-sector/>.

³⁰² See also Chapter 1 of this report on Malign Information Operations.

the Department, technology competition is unlikely to become a core aspect of U.S. foreign policy.

Action for the President:

- **Disseminate a Presidential letter of instruction to Chiefs of Mission that articulates emerging technology as inseparable from U.S. core geopolitical interests.**
 - The instruction should direct each Chief of Mission to develop an emerging technology plan as part of its mission strategy submitted to the Secretary of State.

Actions for the Department of State:

- **The Secretary of State should direct the Deputy Secretary of State for Management and Resources (D/MR) to lead on reorienting and reorganizing the Department for technology diplomacy.**
 - The D/MR position has in the past exercised leadership to oversee significant organizational and resourcing priorities across the Department of State.
 - Past officials in the D/MR position have spearheaded U.S. diplomatic priorities around regional policy (such as the U.S.-Pakistan Strategic Dialogue), foreign assistance, civilian response, and international economic issues.
 - D/MR should provide direction around immediate and long-term planning to coordinate disparate offices and bureaus within the Department of State, develop technological expertise at all levels of the Foreign and Civil Service, and ensure that policy direction is aligned with management, personnel, and resource actions needed to achieve reorientation with urgency and sustainability.
 - D/MR should also provide leadership for executing the ISTS.
- **Generate a comprehensive proposal for immediate funding needs with a request to Congress for supplemental appropriations.**
 - The Department of State should prepare and submit to Congress within 60 days a request for immediate funding needs to address personnel shortages and programmatic efforts to further U.S. diplomacy around emerging technology. The Department should seek funding through supplemental appropriations to avoid lags in the budget cycle.
- **Expedite building out a dedicated bureau for emerging technology diplomacy.**
 - The Department of State should expedite and prioritize efforts to staff, resource, and build out a bureau for emerging technology diplomacy.
 - The Bureau of Cyberspace Security and Emerging Technologies (CSET Bureau),

formally approved in January 2021,³⁰³ is intended to focus on security challenges associated with cyberspace and emerging technologies.³⁰⁴ The Commission proposes that the CSET Bureau be established with a broad aperture to address diplomatic efforts across the security, economic, human rights and regional dimensions of foreign policy. It should serve as a clearinghouse to assess strategic, budgetary and personnel priorities on emerging technology policy across the Department. The Bureau should have responsibilities for managing high-level dialogues with allies and partners to further progress and cooperation, coordinating policy, standards, and digital development assistance with U.S. agencies, and promoting AI and emerging technology advocacy within the Department.

- The Department should assess where the CSET Bureau should be placed to best achieve those objectives, but must ensure its creation is not further delayed.
- The Bureau should be led by a high-profile Assistant Secretary or Ambassador-at-Large. If the Department appoints an Assistant Secretary to head the Bureau and lead coordination across the Department, it should consider creating a separate Ambassador-at-Large position to lead diplomacy with foreign counterparts on cybersecurity and emerging technology.
- **Develop a comprehensive plan to reorganize technology diplomacy under a new Under Secretary.**
 - The Department of State should develop a comprehensive proposal to **establish an Under Secretary for Science, Research and Technology (Q)**. State/Q would bring together the elements for a robust, coordinated approach to science and technology diplomacy in the context of great power competition - with a focus on emerging technology.³⁰⁵
 - State/Q would also work with the Director for Foreign Assistance to manage a new allocated account for digital democracy and emerging technologies and lead implementation of the ISTS across the U.S. government.
 - The plan should also consider establishing Deputy Assistant Secretaries for Science and Technology in each regional bureau. These positions would provide a critical link between technology officers and senior leadership.
 - Currently the Department lacks a core of senior, career officials with deep and broad technology policy expertise. The positions would provide a career path to the senior level for officers focused on technology policy

³⁰³ *Secretary Pompeo Approves New Cyberspace Security and Emerging Technologies Bureau*, U.S. Department of State (Jan. 7, 2021), <https://2017-2021.state.gov/secretary-pompeo-approves-new-cyberspace-security-and-emerging-technologies-bureau/index.html>.

³⁰⁴ For additional details regarding the function and need for the CSET bureau, see *Second Quarter Recommendations*, NSCAI at 88-89 (July 2020), <https://www.nscai.gov/previous-reports/>.

³⁰⁵ These elements should include key, technology-related functions of the proposed CSET Bureau; the Bureau of Oceans, Environment and Science (OES); the Office of the Science and Technology Adviser to the Secretary (STAS); the Coordinator for Cyber Issues (S/CCI); the Bureau for Economic and Business Affairs (EB); the Bureau for Democracy, Human Rights, and Labor (DRL); and the Center for Analytics.

and would enable senior level advocacy for reforms needed to effectively manage technology policy.

- Given the urgent need to enhance the Department’s technology diplomacy capacity and the likely long-term nature of the process of establishing a new Under Secretary, efforts to implement this recommendation should proceed in parallel with the Commission’s other organizational recommendations.
- **Establish a diplomatic presence in major U.S. and foreign technology hubs.**
 - The Department of State should enhance its presence in major foreign and U.S. technology hubs, supported by establishing a cadre of dedicated technology officers at U.S. missions to strengthen diplomatic advocacy, improve technology scouting, and inform policy and foreign assistance choices.
 - The Department should accelerate plans to establish 12 Regional Technology Officer positions around the world,³⁰⁶ and further describe how these officers will enhance U.S. technology competitiveness with partners such as the Foreign Commercial Service, USAID and DFC. These officers should also scout technology initiatives that can enhance our diplomatic and development capabilities.
 - The Department should re-establish a permanent presence in Silicon Valley, which it initiated in 2014, and established dedicated positions in 2015-2016. These positions and State’s presence were discontinued when an OMB hiring freeze was implemented in January 2017.
 - In addition, the Diplomat in Residence program—with presence in 16 regions at Universities across America³⁰⁷—should be re-purposed beyond recruitment to include public diplomacy, technology scouting and engagement with foreign government and commercial entities active across America. Domestic insight is a valuable input into foreign policy and will increase public confidence in and support for America’s international technology leadership.
- **Incorporate AI and emerging technology training modules into Foreign Service institute (FSI) courses.**
 - The Department of State should incorporate mandatory AI and emerging technology-related modules into key FSI training courses, including the Ambassadorial Seminar, the Deputy Chiefs of Mission course, Political and Economic Tradecraft courses, and A-100 orientation training classes. FSI should also develop a stand-alone course on emerging technologies and foreign policy.
 - The Department should partner with academic and private sector organizations to access the leading edge of technology education, while also building a more robust technology fellows program for exchanges with industry.

³⁰⁶ *Key Topics*, Office of the Science and Technology Adviser at the U.S. Department of State (last accessed Dec. 15, 2020), <https://www.state.gov/key-topics-office-of-the-science-and-technology-advisor/>.

³⁰⁷ *Diplomats in Residence*, U.S. Department of State (last accessed Feb. 2, 2021), <https://careers.state.gov/connect/dir/>.

Actions for Congress:

- **Expedite necessary reorganization of the Department of State by passing legislation to create an Under Secretary for Science, Research and Technology (Q).**
 - Congress should act to create the State/Q position and consolidate disparate science and technology efforts in the Department in a single division. There is urgent need for such reorganization and Congress can empower the Department of State by introducing and passing legislation to expedite the reorientation.
- **Appropriate funds to support immediate augmentation of the U.S. diplomatic corps.**
 - Congress should provide robust funding for hiring and training of needed personnel to enable the Department of State's reorientation and support the Department's international efforts to promote U.S. values and standards in AI, data, and associated emerging technologies.
 - The Commission recommends that Congress provide at least \$8 million in supplemental appropriations for immediate hiring of staff to address emerging technology needs across the Department's offices and bureaus, to establish a diplomatic presence in major U.S. and foreign technology hubs, and to develop FSI courses.
 - See the Funding Table Appendix to this report for a detailed breakdown of the proposed appropriations.
- **Appropriate funds to support the CSET Bureau.**
 - The Commission recommends a minimum of \$20 million to establish the CSET Bureau.
 - See the Funding Table Appendix to this report for a detailed breakdown of the proposed appropriations.
- **Appropriate funds to support critical diplomatic efforts, programs, and foreign operations in AI, emerging technologies, and data.**
 - Further funding is needed to enable the Department of State to advance responsible AI aligned with U.S. and like-minded values.
 - While details of funding needs should reflect input from the Department of State, the Commission recommends, at a minimum, that Congress issue a supplemental appropriation for no less than \$37 million, as a subset of the proposed \$300 million described earlier in this Blueprint for Action, for the following urgent needs:
 - Public diplomacy messaging and engagement to support democratic values and raise awareness of U.S. leadership in AI innovation as well as the risks of unwanted technology transfer and authoritarian digital practices;

- AI exchange programs to promote U.S. values and fund participation by developing countries participation in multilateral AI activities;
 - Programs to showcase American innovation and promote the ethical use of AI through, including the American Spaces, TechCamp, MakerSpaces, and U.S. Speakers programs³⁰⁸;
 - Partnership development and advancement of scientific norms through the U.S. Science Envoys and Embassy Science Fellows programs;
 - Diplomatic operations and programs around international AI cooperation, including support for initiatives of the ETC;
 - Promotion of human rights and fundamental freedoms in the AI context;
 - Maintaining U.S. lead in the use of AI for military applications through cooperation with allies and partners;
 - Ensure political and policy congruence with allies and partners on the use of AI-enabled weapons systems;
 - Ensure continued interoperability among the U.S. and its allies and partners;
 - Training and capacity building for foreign governments on emerging technologies to support responsible innovation;
 - Reporting to counter malign influence in AI ecosystems;
 - Empower global AI-focused S&T entrepreneurship through the U.S. Global Innovation through Science and Technology (GIST) Initiative³⁰⁹; and
 - Public diplomacy initiatives on international AI standards as well as tracking and reporting on public opinion related to AI.
- See the Funding Table Appendix to this report for a detailed breakdown of the proposed appropriations.

³⁰⁸ See, e.g., *Managing American Spaces*, U.S. Department of State (last accessed Feb. 1, 2021), <https://americanspaces.state.gov/>; *TechCamp*, U.S. Department of State (last accessed Feb. 1, 2021), <https://techcamp.america.gov/>; *Program Description*, World Learning (last accessed Feb. 1, 2021), <https://www.worldlearning.org/program/u-s-speaker-program/>.

³⁰⁹ See *About GIST*, GIST (last accessed Feb. 1, 2021), <https://www.gistnetwork.org/about>.

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Chapter 15: A Favorable International Technology Order

Annex: Emerging Technology Coalition

This Annex provides a framework and overarching agenda for global cooperation on artificial intelligence (AI) and emerging technologies. The Annex includes guidance on concrete, operational projects, applications, and implementation mechanisms for collaborative AI work across seven critical areas. Collaborative work in these areas will serve to further AI consistent with democratic values and strengthen the ties that connect the United States with its allies and partners. This Annex is intended to provide guidance to the Emerging Technology Coalition (ETC) and may assist officials in prioritizing bilateral and multilateral collaborative efforts outside the context, to include engagement with multilateral initiatives across the AI landscape.

Critical Area #1 - Developing and Operationalizing Standards and Norms

- *Objectives:*
 - Advance common, democratic norms and values to govern and guide responsible AI and the research, development, and application of emerging technologies globally.³¹⁰
 - Promote international AI norms and standards that uphold democratic values, building on guiding documents such as the OECD AI Principles and efforts to operationalize principles, as reflected in the Commission’s *Key Considerations for Responsible Development & Fielding of Artificial Intelligence*.³¹¹
 - Coordinate positions taken by partner states’ governmental delegations and, where appropriate, national (non-government) standards institutes accredited to international technical standards organizations to support development of secure, reliable, and trusted technologies, and to ensure ethical and technical integrity, endorse standards that comport with democratic values, and maintain the neutrality of these organizations.³¹²
- *Priority areas for coordination.* The ETC should seek to align with allies and partners and prioritize efforts in development of international technical standards in the following priority areas:
 - Safety and reliability;

³¹⁰ See *Interim Report and Third Quarter Recommendations*, NSCAI at 213 (Oct. 2020), <https://www.nscai.gov/previous-reports/>.

³¹¹ See *Key Considerations for Responsible Development & Fielding of Artificial Intelligence*, NSCAI at 7-14 (July 2020), <https://www.nscai.gov/previous-reports/> [hereinafter *Key Considerations*].

³¹² Key technical standards organizations include: the International Organization for Standardization (ISO), International Electrotechnical Commission (IEC), Institute of Electrical and Electronic Engineers (IEEE), the UN International Telecommunication Union’s Telecommunication Standardization Sector (ITU-T), and the Third Generation Partnership Project (3GPP). See *Interim Report and Third Quarter Recommendations*, NSCAI at 205 (Oct. 2020), <https://www.nscai.gov/previous-reports/>.

- Privacy-enhancing technologies, including privacy-preserving machine learning (PPML), allied cryptographic code, and other privacy-enhancing technologies;
 - Data sharing, labelling, and related documentation for data, models, and systems;
 - Assessing system performance and characterize blind spots per shared values (including fairness, interpretability, reliability, and secure use of AI technologies as part of integrated systems);
 - Robustness to ensure models are resilient to adversarial examples and model inversion, while red teaming with allies on competitors' attempts to undermine AI-enabled systems;
 - Trust in human-machine teaming and development of common standards and benchmarks to assess risks in settings of varying complexity and uncertainty;
 - Traceability, focused on audit trail requirements per mission needs for high-stakes AI systems including safety-critical applications; and
 - Interoperability including benchmarks that assess reliability of produced model explanations.
- *Mechanisms for Coordination.*
 - In addition to coordinating efforts through the ETC, the U.S. government, led by the Department of State and in coordination with the National Institute of Standards and Technology (NIST) and its AI Standards Coordinator, should engage with democratic nations to align positions on standards that are critical to mutual security and defense.
 - The Department of State, as the Commission has recommended, is in the process of placing regional technology officers in major foreign technology hubs.³¹³ This development will facilitate diplomatic efforts towards coordinating positions with allies and partners.³¹⁴
 - As the Commission recommended in its *Third Quarter Recommendations*³¹⁵ and elsewhere in this Report, NIST and other agencies should consider the Commission's *Key Considerations for Responsible Development and Fielding of AI*. The *Key Considerations* include operational guidance on standards critical to responsible AI and national security, including for technical standards on testing and evaluation, verification and validation (TEVV).³¹⁶

³¹³ See *Second Quarter Recommendations*, NSCAI at 89 (July 2020), <https://www.nscai.gov/previous-reports/>.

³¹⁴ See *Interim Report and Third Quarter Recommendations*, NSCAI at 213 (Oct. 2020), <https://www.nscai.gov/previous-reports/>. These recommendations have been reprised and built upon in the Chapter 15 Blueprint for Action.

³¹⁵ See *Interim Report and Third Quarter Recommendations*, NSCAI at 213 (Oct. 2020), <https://www.nscai.gov/previous-reports/>.

³¹⁶ The Commission recommends that NIST provide a set of standards, performance metrics, and tools for qualified confidence in AI models, data, and training environments, and predicted outcomes. The Blueprint for Action also recommends that NIST

- Coordination on technical standards should include the work of international standards organizations as well as coordinated work on operationalizing AI norms and principles. The Global Partnership on AI's (GPAI) Data Governance Working Group can provide particularly salient best practices for engineering and implementing data sharing, pooling, and collecting initiatives.³¹⁷ The Organization for Economic Co-Operation and Development (OECD) is also a critical forum for technical standards and guidelines, particularly in data sharing and responsible AI.³¹⁸

Critical Area #2 - Joint Research and Development on AI and Digital Infrastructure

- *Objectives:*
 - Identify areas of shared interest conducive to collaborative R&D, such as privacy-enhancing technologies, small data approaches to AI, next-generation materials, prototyping, and high-performance computing, for which there are existing gaps and identify ways to share resources to pursue R&D in those areas.
 - Develop mechanisms to facilitate fundamental and applied R&D projects that involve collaboration among nations, industry partners, and researchers.
 - Projects may also include secure cloud frameworks, sharing best practices on test and evaluation, verification and validation, innovative funding models, international test beds to develop pre-commercial technologies, and leveraging the Commission's proposed Multilateral AI Research Institute for coordination (see the Blueprint for Action for Chapter 15).
 - Pursue collaborative, coordinated efforts to develop and deploy AI applications to benefit humanity at large in areas of global concern such as those embodied in UN Sustainable Development Goals.
- *Priority areas for collaborative R&D—advancing AI technology.*

provide guidance as the science on testing across responsible AI attributes evolves. See the Blueprint for Action for Chapter 7 of this report.

³¹⁷ Jenni Tennison, *An introduction to the Global Partnership on AI's work on data governance*, OECD AI Policy Observatory, (Aug. 21, 2020), <https://oecd.ai/wonk/an-introduction-to-the-global-partnership-on-ais-work-on-data-governance>.

³¹⁸ The OECD has led the international community with its work around AI norms and policy development. The May 2019 Principles on Artificial Intelligence were the first multilateral set of principles adopted by governments. Launched in February 2020, the OECD AI Policy Observatory facilitates dialogue between its global multi-stakeholders, provides evidence-based analysis on 20+ policy areas, promotes the adoption of the AI Principles, and bolsters the advancement and monitoring of trustworthy AI systems that benefit society. The Network of Experts on AI (ONE AI) is an informal advisory group of multi-disciplinary and multi-stakeholder experts from over 30 countries that provides policy, technical, and business expert input to inform OECD analysis and recommendations. The OECD has also developed Guidelines on the Protection of Privacy and Transborder Flows of Personal Data and is working towards principles for trusted government access to data. See generally *OECD AI Policy Observatory*, OECD.AI (last accessed Jan. 5, 2021), <https://oecd.ai/>; *OECD Privacy Guidelines*, OECD (last accessed Jan. 4, 2020), <http://www.oecd.org/digital/ieconomy/privacy-guidelines.htm>.

- **Development of privacy-preserving technology**, such as homomorphic encryption and differential privacy techniques,³¹⁹ to facilitate cross-border AI applications, data sharing, and cooperative efforts.³²⁰
- **Continuous development and adaptation of TEVV systems** to strengthen the development of trustworthy, robust AI is critical to advancing the interests of democratic nations and to understanding how AI systems perform in multi-agent/adversarial contexts.³²¹ Collaboration in this area will contribute to understanding differences among allies on policy, metrics, standards and requirements while creating stronger connections for all users in a full-cycle approach.
- **Development of AI for modeling, simulation, and design** to provide researchers with a larger scope of AI-ready data sets.³²²
- **Development of one- and few-shot learning algorithms**³²³—algorithms that rely on less data—to facilitate future joint R&D and data sharing and improve context-specific interoperability.³²⁴
- **Development of robust allied AI** to reduce vulnerabilities of allied AI systems and training data to adversarial attacks.³²⁵
- **Achieving context-specific interoperability of AI systems** necessary for cross-border AI applications, with a focus on how systems integrate particular AI/ML components.³²⁶ The potential for AI to increase speed of operations will require allies and partners to stress test decision making procedures and communications protocols to ensure interoperability. Interoperability of AI systems is already an

³¹⁹ See the Technical Glossary of AI Terms Appendix of this report for definition of homomorphic encryption and differential privacy techniques. Collaborative research in this area could draw from promising R&D use cases, including the DARPA Brandeis program and the IARPA HECTOR program. See *Brandeis*, DARPA (last accessed Sept. 18, 2020), <https://www.darpa.mil/program/brandeis>; *Homomorphic Encryption Computing Techniques with Overhead Reduction (HECTOR)*, IARPA (last accessed Sept. 18, 2020), <https://www.iarpa.gov/index.php/research-programs/hector>; see also *Key Considerations* at 13 (recommending R&D to advance privacy-preserving technology).

³²⁰ See *First Quarter Recommendations*, NSCAI at 11 (Mar. 2020), <https://www.nscai.gov/previous-reports/>.

³²¹ See *Key Considerations* at 29 (recommending R&D for TEVV of AI systems to improve TEVV and build checks and balances into an AI system). TEVV R&D includes complex system testing to improve understanding of and confidence in emergent performance of composed AI systems and improve methods to understand, predict, and control systems-of-systems to avoid negative outcomes resulting from system interaction. In addition, R&D in a multi-agent scenario will advance the understanding of interacting AI systems, including the application of game theory to varied and complex scenarios, and interactions between cohorts composed of a mixture of humans and AI technologies. See also *First Quarter Recommendations*, NSCAI at 11 (Mar. 2020), <https://www.nscai.gov/previous-reports/>.

³²² The Commission has previously recommended that the United States devote greater resources to AI modeling, simulation, and design. See *First Quarter Recommendations*, NSCAI at 6-13 (Mar. 2020), <https://www.nscai.gov/previous-reports/>.

³²³ See the Technical Glossary of AI Terms Appendix of this report for definition of one shot of few shot learning.

³²⁴ See *First Quarter Recommendations*, NSCAI at 11 (Mar. 2020), <https://www.nscai.gov/previous-reports/>.

³²⁵ See *Key Considerations* at 22 (recommending R&D for “AI security and robustness—to cultivate more robust methods that can overcome adverse conditions; advance approaches that enable assessment of types and levels of vulnerability and immunity; and to enable systems to withstand or to degrade gracefully when targeted by a deliberate attack”); see also *First Quarter Recommendations*, NSCAI at 11 (Mar. 2020), <https://www.nscai.gov/previous-reports/>.

³²⁶ See *Key Considerations* at 7, 29 (recommending collaboration among allies and partners to enable interoperability and trust).

issue at the forefront of defense cooperation and will only grow in importance as technology matures.

- **Development of AI to secure and improve resiliency of supply chains** to protect AI-component supply chains while promoting domestic and allied innovation and to apply AI to improve auditing, mapping, and securing supply chains while ensuring resilience to shocks. Given the inherently cross-border nature of supply chains and their critical role in the international economy around AI and advanced technology, this is a natural area for the United States to work collaboratively with like-minded nations.
- **Additional critical AI research areas** including novel machine learning directions, complex multi-agent scenarios, advanced scene understanding, AI system risk assessment, enhanced human-AI interaction and teaming, and autonomous AI systems.³²⁷
- *Priority areas for collaborative R&D - AI to benefit humanity.* The potential for AI to assist the global community in improving the human condition is immense. Priority areas for international collaboration should include the following.
 - **Environment and climate.** Recognizing the growing view that environmental degradation and climate change represent imperatives for national and international security, the international community must work collaboratively to develop AI-based solutions to address common climate, environmental, and energy challenges.
 - Collaborative initiatives such as the following serve as models for future international efforts:
 - The Partnership between Cross Section Evaluation Working Group and OECD’s Nuclear Energy Agency’s (NEA) Working Party on International Nuclear Data Evaluation Co-operation on International Criticality Safety Benchmark Evaluation Project;³²⁸
 - GEOTHERMICA, a collaboration among 12 European countries and the United States to fund AI specific research on geothermal R&D;³²⁹ and

³²⁷ See Chapter 11 of this report and its associated Blueprint for Action for detail on potential priority areas for AI research.

³²⁸ See *Working Party on Nuclear Criticality Safety (WPNCS)*, OECD Nuclear Energy Agency, <https://www.oecd-nea.org/science/wpncs/>; *International Co-operation in Nuclear Data Evaluation: An Extended Summary of the Collaborative International Evaluated Library Organisation (CIELO) Pilot Project*, NEA No. 7489, OECD Nuclear Energy Agency (2019), <https://www.oecd-nea.org/science/wpec/documents/volume40.pdf>.

³²⁹ GEOTHERMICA combines financial resources and expertise on geothermal energy research and innovation from 16 countries and their regions. It “launches joint projects that demonstrate and validate novel concepts of geothermal energy deployment within the energy system, and that identify paths to commercial large-scale implementation.” One of the three focus areas includes “smart integration into the energy system and operations.” Some of the projects have big data and smart system aspects, such as the French National Project through the Geothermica HEATSTORE project. GEOTHERMICA partners, like the U.S. Lawrence Livermore National Laboratory, have expertise in machine learning. See *About GEOTHERMICA*, GEOTHERMICA (last accessed Sept. 18, 2020), <http://www.geothermica.eu/about-geothermica/>; *French National Project*,

- The International Partnership for Hydrogen & Fuel Cells in the Economy (IPHE),³³⁰ an intergovernmental partnership to facilitate and accelerate transition to clean & efficient energy with the support of AI and machine learning (ML) research.
- **Health, including pandemic detection and response.** The COVID-19 crisis has made clear the need for global collaboration and the potential for AI-enabled solutions.
 - *Smart disease monitoring.* The Commission has recommended global cooperation on smart disease monitoring.³³¹ Such a global initiative, for example, could seek to combine existing data on zoological spills with open source health-related data to create shared, predictive, global disease monitoring models (see Chapter 16 of this report and its associated Blueprint for Action).³³²
 - *Pandemic preparedness, vaccine development, and syndromic surveillance.* Efforts in this space,³³³ include:
 - Development and coordination on international norms and standards to govern use and sharing of international health data, protecting privacy while ensuring timely accessibility of data;
 - Development of privacy standards for genomic datasets;
 - Increased international cooperation in the COVID-19 High Performance Computing Consortium (potentially through GPAI); and
 - Facilitation of international cooperation with DARPA’s work on creating the infrastructure and protocols for data sharing and collaboration at the point of experimentation for drug discovery.
 - *Initiatives to enable long term quality of life.* Collaboration with allies and partners can facilitate the Commission-recommended focus on harnessing AI to help the elderly live independently longer, assist in managing health

Heatstore (last accessed Sept. 18, 2020), <https://www.heatstore.eu/national-project-france.html>; *American Partners, GEOTHERMICA* (last accessed Sept. 18, 2020), <http://www.geothermica.eu/matchmaking/united-states/>.

³³⁰ Members of the partnership include the United States as well as Australia, China, Germany, Japan, Russia, Austria, Costa Rica, Iceland, ROK, South Africa, Brazil, India, the Netherlands, Canada, France, Italy, and Norway. See *International Partnership for Hydrogen and Fuel Cells in the Economy*, U.S. Department of Energy (last accessed Sept. 18, 2020), <https://www.energy.gov/eere/fuelcells/international-partnership-hydrogen-and-fuel-cells-economy>; *International Partnership for Hydrogen and Fuel Cells in the Economy*, IPHE (last accessed Sept. 18, 2020), <https://www.iphe.net/>.

³³¹ See *Interim Report and Third Quarter Recommendations*, NSCAI at 153 (Oct. 2020), <https://www.nscai.gov/previous-reports/>.

³³² Chapter 16 and its Blueprint for Action recommends the United States pursue global cooperation on smart disease monitoring.

³³³ Jason Matheny, et al., *The Role of AI Technology in Pandemic Response and Preparedness: Recommended Investments and Initiatives*, NSCAI (June 25, 2020), <https://www.nscai.gov/white-papers/covid-19-white-papers/>.

and daily tasks, and improve the quality of life particularly through the application of AI to biomedicine.³³⁴

- The National Nanotechnology Initiative’s U.S.-EU Communities of Research³³⁵ along with various national-level efforts by partner nations³³⁶ should serve as models for larger-scale international collaboration.
- **Food security.** The United States emphasizes agriculture-led growth, resilience, nutrition, and water security, sanitation and hygiene in its foreign assistance programs. Enhancing the security of water and food of partner nations is needed to disrupt the vicious cycle of poverty, hunger and conflict.³³⁷
 - Agricultural sectors are increasing the use of data-driven technologies such as robotics, satellites, GPS, drones. Significant data sets are being generated about crop growth, soil characteristics, and weather conditions.³³⁸
 - AI and ML-based algorithms can amplify the data sets and hardware to improve real-time monitoring and analysis of agricultural and distribution processes. This can improve efforts to assess needs, enhance productivity and security, build local capacities and productivity while minimizing environmental impact.
- **Disaster relief.** AI-enabled technologies are being used to address a range of disaster scenarios and further work on an international basis should be explored. The World Economic Forum is among those groups calling for greater international collaboration in order to realize the benefits of AI to specifically include the area of disaster relief.³³⁹
 - Climate and weather-related disasters like hurricanes, wildfires, and flooding are on the rise and AI is already being applied to mitigate the effects by locating survivors using unmanned aerial vehicles; removing debris after a disaster, deploying robots to communicate with victims,

³³⁴ See Chapter 11 of this report and its associated Blueprint for Action for its recommendation for the United States to take some of humanity’s biggest challenges.

³³⁵ *NanoEHS CORs*, US-EU Nanotechnology Communities of Research (CORs) (last accessed Sept. 18, 2020), <https://us-eu.org/communities-of-research/>.

³³⁶ See, e.g., Jeff Mason, et al., *An Overview of Clinical Applications of Artificial Intelligence*, Canadian Agency for Drugs and Technologies in Health (Sept. 2018), https://www.cadth.ca/sites/default/files/pdf/eh0070_overview_clinical_applications_of_AI.pdf.

³³⁷ Feed The Future (last accessed Feb. 3, 2021), <https://www.feedthefuture.gov/>.

³³⁸ *Automation and Artificial Intelligence in Agriculture: The Future of Maintaining Food Security and Sustainable Intensification*, Frontiers (last accessed Feb. 3, 2021), <https://www.frontiersin.org/research-topics/15206/automation-and-artificial-intelligence-in-agriculture-the-future-of-maintaining-food-security-and-su>.

³³⁹ The World Economic Forum has noted 160 million people a year are at risk from natural disasters and sees great benefit in AI from “reducing the time to assess damage to monitoring social media to more quickly and effectively deliver aid” while “sharpen[ing] the decisions of relief workers on the front lines.” Ashley van Heteren, et al., *Natural Disasters are Increasing in Frequency and Ferocity. Here’s How AI Can Come to the Rescue*, World Economic Forum (Jan. 14, 2020), <https://www.weforum.org/agenda/2020/01/natural-disasters-resilience-relief-artificial-intelligence-ai-mckinsey/>.

employing edge technology to obtain the most up to date data, running predictive simulations and leveraging social media reporting.

- The DoD is partnering with DoE and Microsoft to develop “deep-learning artificial intelligence algorithms to provide near-real-time data to improve the decision-making of first responders engaged in natural disasters and humanitarian assistance efforts”³⁴⁰ and countries like Singapore are working with the JAIC on this particular National Mission Initiative.³⁴¹
- The United States can work with its allies and partners to effectively predict, model, prepare for and respond to disasters, as the Commission recommends in Chapter 11 of this report.³⁴²
- **Civilian space cooperation.** The United States and other space agencies employ AI to tackle a range of space missions—including for visualization of space objects and situational awareness, tracking space debris for satellite collision avoidance, roving the lunar surface, deep space exploration with autonomous systems, and detection of asteroids that could threaten Earth.³⁴³
 - For safe satellite navigation around space debris, the European Space Agency (ESA) and the UK Space Agency both have AI initiatives underway, which suggest potential opportunities for closer U.S. collaboration.³⁴⁴ ESA has already established a partnership with Stanford.³⁴⁵
 - India is also building its space program and has deployed an AI-powered Moon rover.³⁴⁶
 - Russia and China appear to be developing technological solutions to the space collision problem, which could present an area for mutually beneficial cooperation. AI-enabled robotic assistants are also being developed for the International Space Station.³⁴⁷

³⁴⁰ David Vergun, *DOD Partners With Agencies to Use AI for Disaster Relief, Humanitarian Relief*, DOD News (Aug. 20, 2020), <https://www.defense.gov/Explore/News/Article/Article/2319945/dod-partners-with-agencies-to-use-ai-for-disaster-humanitarian-relief/>.

³⁴¹ Prashanth Parameswaran, *What’s in the New US-Singapore Artificial Intelligence Defense Partnership?*, The Diplomat (July 1, 2019), <https://thediplomat.com/2019/07/whats-in-the-new-us-singapore-artificial-intelligence-defense-partnership/>.

³⁴² See the discussion in Chapter 11 and its associated Blueprint for Action on using AI to tackle some of humanity’s biggest challenges.

³⁴³ On asteroids, see *Deep Asteroid*, NASA (May 27, 2016), <https://open.nasa.gov/innovation-space/deep-asteroid/>.

³⁴⁴ *AI Challenged to Stave off Collisions in Space*, European Space Agency (Oct. 9, 2019), https://www.esa.int/Enabling_Support/Space_Engineering_Technology/AI_challenged_to_stave_off_collisions_in_space; Angelica Mari, *UK Government Seeks Innovations to Tackle Space Debris*, Computer Weekly (May 28, 2020), <https://www.computerweekly.com/news/252483762/UK-government-seeks-innovations-to-tackle-space-debris>.

³⁴⁵ Andrew Myers, *Stanford Develops an AI Navigation System for a Future Satellite ‘Tow Truck’*, Stanford News (Feb. 1, 2019), <https://news.stanford.edu/2019/02/01/stanford-spurs-ai-navigation-space-rendezvous-software/>.

³⁴⁶ Leslie D’Monte, *Chandrayaan-2 Pragyan Shows How AI is Helping Space Exploration*, Mint (Sept. 6, 2019), <https://www.livemint.com/technology/tech-news/chandrayaan-2-pragyan-shows-how-ai-is-helping-space-exploration-1567764065716.html>.

³⁴⁷ Mike Wall, *New, Emotionally Intelligent Robot CIMON 2 Heads to Space Station*, Space.com (Dec. 5, 2019), <https://www.space.com/cimon-2-artificial-intelligence-robot-space-station.html>.

- *Methods to implement collaborative R&D.* The ETC should also explore vehicles to enable R&D collaboration among government partners and non-governmental organizations.
 - Collaboration must include not only government-to-government efforts but also methods to partner with researchers at academic research centers and in the private sector.
 - Existing science and technology agreements between governments may provide the legal foundation for cooperation but detail will depend on the arrangement at issue.
 - The ETC should prioritize approaches that would facilitate the pooling of resources, reduce redundancies, and support development and socialization of best practices.
 - In addition, the ETC should examine challenges to cross-border, collaborative R&D—such as those around data privacy and data sharing between the United States and European Union—and explore solutions to overcome those challenges.
- Potential methods to implement and further collaborative R&D include:
 - Establishment of the **Multilateral AI Research Institute (MAIRI)**. Proposed by the Commission in this report, MAIRI will serve as a center for multilateral research to coordinate joint efforts to develop technologies and align norms that advance responsible, human-centric, and privacy-preserving AI/ML that better societies.
 - Prioritization of R&D work of the **Global Partnership on AI (GPAI)**. The ETC should leverage existing frameworks wherever possible, and GPAI, supported currently by Canada’s International Center of Expertise in Montréal for the Advancement of Artificial Intelligence (ICEMAI), and France’s National Institute for Research in Digital Science and Technology (INRIA),³⁴⁸ is among the most promising multilateral, multi-stakeholder initiatives to pursue collaborative R&D and advance AI technology for common causes. The Commission has proposed a

³⁴⁸ The EU intends to establish Centres of Excellence and Digital Innovation Hubs focused on AI. ICEMAI works with the Government of Canada’s Advisory Council on Artificial Intelligence, Forum IA Quebec, and the International Observatory on the Societal Impacts of Artificial Intelligence and Digital Technologies and is supported by the governments of Canada and Quebec with up to \$15 million in funding over five years. INRIA was launched in February 2020 and has a contract with the Government of France to focus on “speeding up development of France’s scientific and technological leadership, as part of a Europe-wide approach,” including prioritizing AI and other digital technologies to meet societal challenges, constructing European research and innovation spaces, strengthening the tech industrial base, reinforcing public policies, and developing leading research universities. See *Communication Artificial Intelligence for Europe*, European Commission (Apr. 25, 2018), <https://ec.europa.eu/digital-single-market/en/news/communication-artificial-intelligence-europe>; *The Global Partnership on Artificial Intelligence Officially Launched*, Montreal International (June 15, 2020), <https://www.montrealinternational.com/en/news/the-global-partnership-on-artificial-intelligence-officially-launched/>; *INRIA: For Scientific, Technological and Industrial Leadership in Digital Technology*, Government of France (Feb. 24, 2020), <https://www.gouvernement.fr/en/inria-for-scientific-technological-and-industrial-leadership-in-digital-technology>.

greater role for U.S. researchers through a U.S.-based center of expertise, leveraging the NSF National AI Research Institutes.³⁴⁹

- Creation of a **joint emerging tech investment consortium**. Modeled on In-Q-Tel, the consortium would spur investment by the United States and foreign partners in early-stage companies to further development of AI technology that advances and/or protects democratic values. The effort would benefit the United States and its allies and partners through a cross-border platform to engage with start-ups and entrepreneurs in the AI and emerging tech space.
 - Within the U.S. government, this effort should draw on State Department's Regional Technology Officers, the Foreign Commercial Service, and USAID missions to identify R&D and prototypes to advance U.S. diplomatic, development, and commercial interests.
- Launching **multilateral innovation prize competitions**. Modeled on Defense Advanced Research Projects Agency (DARPA) Challenges and XPRIZE Foundation competitions, international innovation prize competitions sponsored by two or more governments would incentivize R&D in fundamental AI or around specific applications necessary for national security and help to pool resources and talent with allies and industry.³⁵⁰
- Fostering **allied research at U.S. national labs**. The ETC should consider recommendations for increasing research by allies (potentially a subset of the ETC membership) at U.S. national labs on sensitive topics. Although there are limitations on U.S. national labs to allow foreign researchers, domestically housed research efforts would limit concerns around cross-border data-sharing and cybersecurity and could prove fruitful in R&D necessary for defense and security applications.
- Development of an **R&D matching platform and a global horizon-scanning capability**. The platform would connect researchers and their projects with funders and partners (governments, philanthropists, venture capitalists, companies, research institutions), providing the United States Government with increased visibility into research trends. A horizon-scanning capability of global R&D would complement these efforts and draw on open-source data to give policymakers greater understanding of relevant discoveries and key trends in the field.³⁵¹
- Development of an **international test bed for TEVV**. An international test bed for TEVV could be modeled on the National AI Research Institutes³⁵² or the

³⁴⁹ See Implementation Plan to Chapter 15: A Favorable International Digital Order.

³⁵⁰ *AI To Solve Global Issues*, XPRIZE (last accessed Sept. 18, 2020), <https://www.xprize.org/prizes/artificial-intelligence>.

³⁵¹ Melissa Flagg & Paul Harris, *System Re-engineering: A New Policy Framework for the American R&D System in a Changed World*, Center for Security and Emerging Technology (Sept. 2020), <https://cset.georgetown.edu/research/system-re-engineering/>.

³⁵² The National AI Research Institutes is a joint government effort among the National Science Foundation (NSF), U.S. Department of Agriculture (USDA) National Institute of Food and Agriculture (NIFA), U.S. Department of Homeland Security (DHS) Science & Technology Directorate (S&T), and the U.S. Department of Transportation (DOT) Federal Highway

Commission-recommended creation of a NIST-sponsored third-party testing center³⁵³, but with a cross-border focus, as well as on the AI4EU project.³⁵⁴

- **Improved collaboration** between centers of excellence, research institutes, and industry consortia through additional coordination by partner governments. This concept would leverage existing and soon to be established centers like the Multilateral AI Research Institute (MAIRI), European Union Centres of Excellence, European AI-related Digital Innovation Hubs, the U.S. National AI Research Institutes program, General Services Administration’s AI Center of Excellence (in partnership with the Departments of Agriculture and Health and Human Services as well as the Joint Artificial Intelligence Center (JAIC)), the Alan Turing Institute in the United Kingdom, and the Montreal Institute for Learning Algorithms (Mila),³⁵⁵ the Alberta Machine Intelligence Institute (Amii),³⁵⁶ and the Vector Institute for Artificial Intelligence in Canada.³⁵⁷ On the U.S. side, this could involve building on industry and academic efforts like the Stanford Institute for Human-Centered Artificial Intelligence.³⁵⁸
- Fostering of **binational R&D foundations**. ETC members may consider developing targeted, binational R&D efforts modeled on the unique binational foundations that facilitate U.S.-Israel and U.S.-India R&D on cutting edge issues.³⁵⁹ These can serve as models for other allies and partners to convene international researchers.

Critical Area #3 - Promoting Democracy, Human Rights, and the Rule of Law

- *Objectives:*

Administration (FHWA). See *National Artificial Intelligence (AI) Research Institutes*, NSF (last accessed Sept. 18, 2020), https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=505686.

³⁵³ See Chapter 8 of this report and its associated Blueprint for Action for its recommendation for Congress to authorize NIST to sponsor a University Affiliated Research Center (UARC), Federally Funded Research & Development Center (FFRDC), and/or a lab to provide independent, third-party testing.

³⁵⁴ The AI4EU project was founded by the European Commission under the H2020 program to establish the first European AI On-Demand Platform and Ecosystem. The Platform is designed to support the AI ecosystem and provide a forum to share AI resources from European projects. See *About the Project*, AI4EU (last accessed Sept. 18, 2020), <https://www.ai4eu.eu/about-project>.

³⁵⁵ *AI for Humanity*, Mila (last accessed Sept. 18, 2020), <https://mila.quebec/ia-dans-la-societe/>.

³⁵⁶ *Artificial Intelligence For Good and For All*, Amii (last accessed Sept. 18, 2020), <https://www.amii.ca/>.

³⁵⁷ See *Pan-Canadian AI Strategy*, CIFAR (last accessed Feb. 4, 2021), <https://www.cifar.ca/ai>; *About Us*, Vector Institute for Artificial Intelligence (last accessed Sept. 18, 2020), <https://vectorinstitute.ai/about/>.

³⁵⁸ See *Stanford Institute for Human-Centered Artificial Intelligence* (last accessed Sept. 18, 2020), <https://hai.stanford.edu/welcome>.

³⁵⁹ The U.S. has strong research ties to Israel through the Binational Science Foundation (BSF) and the Binational Industrial Research & Development Foundation (BIRD). See *About the BSF*, U.S.-Israel Binational Science Foundation (last accessed Feb. 3, 2021), <https://www.bsf.org.il/about/>; *What is BIRD?*, U.S.- Israel Binational Industrial Research and Development (last accessed Feb. 3, 2021), <https://www.birdf.com/what-is-bird/>. The Indo-U.S. Science and Technology Forum (IUSSTF) oversees the United States–India Science & Technology Endowment Fund (USISTEF) which supports and fosters joint applied R&D. *About the Fund*, Indo-U.S. Science and Technology Forum (last accessed Feb. 3, 2021), <https://www.iusstf.org/usistef/us-india-science-technology>.

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- Collaborative, coordinated efforts to counter anti-democratic uses of AI and emerging technologies through coordinated policy, regulatory alignment (such as end-user export restrictions), and technology deployment.
- Potential priorities include countering censorship, countering malign information operations, and promoting democratic models of surveillance technology, although the ETC should explore a range of potential applications.
- Furthering these normative priorities will build on implementation methods addressed in other Critical Areas -- especially #2 (joint R&D), #5 (protecting and promoting innovation), and #7 (the International Digital Democracy Initiative).
- *Countering censorship and authoritarian uses of technology*
 - The ETC should explore efforts to use AI and associated technologies to further internet freedom and counter censorship across the world. This work should be designed to implement the principles adopted in November 2020 by the Freedom Online Coalition, a partnership of 32 governments aligned around promoting human rights and individual freedom.³⁶⁰
 - The United States should leverage the Open Technology Fund, created by the FY 2021 NDAA, to support this effort, as well as related efforts by the Bureau of Democracy, Human Rights, and Labor (DRL) at the Department of State.³⁶¹
 - The ETC should coordinate efforts in this space with the Council of Europe's Ad Hoc Committee on AI, established in November 2019 to focus on development, design and application of AI in areas of human rights, democracy, and the rule of law.³⁶²
 - To promote private sector conduct that comports with shared democratic values, the ETC should develop a proposal for end-user controls that would disincentivize

³⁶⁰ See Joint Statement on Artificial Intelligence and Human Rights, Freedom Online Coalition (last accessed Jan. 5, 2021), <https://freedomonlinecoalition.com/wp-content/uploads/2020/11/FOC-Joint-Statement-on-Artificial-Intelligence-and-Human-Rights.pdf>.

³⁶¹ The FY 2021 NDAA created the Open Technology Fund as Section 309A of the US International Broadcasting Act of 1994. Pub. L. 116-283, sec. 1299P, William M. (Mac) Thornberry National Defense Authorization Act for Fiscal Year 2021, 134 Stat. 3388 (2021). Congress has since appropriated \$20 million to the fund. See Joint Explanatory Statement, Division K - Department of State, Foreign Operations, and Related Programs Appropriations Act, 2021 at 23 (2021), <https://www.appropriations.senate.gov/imo/media/doc/Division%20K%20-%20SFOPS%20Statement%20FY21.pdf> (enacted in Pub. L. 116-260, the Consolidated Appropriations Act, 2021). The Department of State's Internet Freedom and Business & Human Rights Section (IFBHR), within DRL, leads United States Government policy and engagement to protect human rights online. See *Internet Freedom: Fact Sheet*, U.S. Department of State (Nov. 17, 2017), <https://2017-2021.state.gov/internet-freedom/index.html>. IFBHR works across the United States Government, with democratic nations, with civil society, and with the Freedom Online Coalition. IFBHR's program includes funding development of censorship-defeating peer-to-peer communications technologies. See *Internet Freedom: Advancing and Promoting Peer-to-Peer Communications Technologies*, U.S. Department of State (Feb. 13, 2020), <https://2017-2021.state.gov/internet-freedom-advancing-and-promoting-peer-to-peer-communications-technologies/index.html>.

³⁶² Isaac Ben-Israel, et al., *Towards Regulation of AI Systems: Global Perspectives on the Development of a Legal Framework on Artificial Intelligence (AI) Systems Based on the Council of Europe's Standards on Human Rights, Democracy and the Rule of Law*, CAHAI Secretariat (Dec. 2020), <https://rm.coe.int/prems-107320-gbr-2018-compli-cahai-couv-texte-a4-bat-web/1680a0c17a>.

private companies from exporting AI and associated technologies that may be used to suppress and violate human and civil rights.³⁶³

- *Countering Malign Information Operations*
 - Malign information operations present a growing international challenge that is compounded by the use of AI/ML technologies.
 - This ETC should examine coordinated efforts (outside of the intelligence space) to counter disinformation and other information operations. Joint efforts include detecting, moderating, identifying, and classifying malign information, developing standards and best practices, and training experts.
 - The Commission recommends creation of an **International Task Force to Counter and Compete Against Disinformation**.³⁶⁴ An International Task Force to Counter and Compete Against Disinformation (ITF-CCAD) could be established as a joint project between the United States and multiple countries, as well as the EU and NATO, to further joint efforts to enable content moderation and detection of disinformation, develop standards for identifying and classifying misinformation and disinformation (to include deepfake detection), and share best practices and lessons learned with allies. The private sector, academia, and civil society organizations would be important partners in this effort.
 - The ITF-CCAD should draw best practices from, and should work in coordination with, the Global Internet Forum to Combat Terrorism,³⁶⁵ along with efforts of the Department of State's Global Engagement Center's (GEC) Technology Engagement Team (TET); the Federal Bureau of Investigation's Foreign Influence Task Force (FITF); the European External Action Services' Strategic Communication Task Force; the EU "Team Europe" initiative; and the NATO/StratCom Center of Excellence. IFT-CCAD should additionally prioritize stress testing rapid response mechanisms and look to fund open-source research.
 - It should explore generating best practices for non-tech solutions, such as media literacy, free press,³⁶⁶ civic engagement initiatives, drawing on notable work by the Center for Strategic and International Studies' Defending Democratic

³⁶³ See Chapter 14 Blueprint for Action. See also *Guidance on Implementing the UN Guiding Principles for Transactions Linked to Foreign Government End-Users for Products or Services with Surveillance Capabilities*, U.S. Department of State (last accessed Jan. 4, 2021), <https://www.state.gov/wp-content/uploads/2020/10/DRL-Industry-Guidance-Project-FINAL-1-pager-508-1.pdf>.

³⁶⁴ See the Malign Information Blueprint for Action for Chapter 1 of this report, for further detail on this proposal.

³⁶⁵ *About*, Global Internet Forum to Combat Terrorism (last accessed Jan. 5, 2021), <https://www.gifct.org/about/>.

³⁶⁶ Civil society in Taiwan has responded to the threat from disinformation in a number of ways from demonstrating outside compromised media firms, educating senior citizens on the ways they may be exposed to disinformation, and the establishment of robust fact checking groups, such as the Taiwan Fact Check Center, MyGoPen, Cofacts, and Rum Toast. These groups have worked with both government and social media platforms to not just identify and remove disinformation, but also forensically trace disinformation back to sources in China. See *Audrey Tang on Taiwan's Digital Democracy, COVID-19, and Combating Disinformation*, The Stimson Center (Mar. 18, 2020), <https://www.stimson.org/2020/interview-with-taiwan-digital-minister-audrey-tang/>.

Institutions project and the German Marshall Fund's Alliance for Securing Democracy.

- *Surveillance technology that comports with democratic values.*
 - The ETC should dedicate a multi-faceted effort to promoting surveillance technology that supports democratic values.³⁶⁷ In particular, the effort should focus on (a) promoting technology that delivers a degree of protection for individual privacy and for civil rights and civil liberties and limits the use of data collected or combined in ways that enable re-identification, and (b) countering the global deployment of surveillance technology used to undermine democratic values and individual rights.
 - Doing so will require coordinated R&D, messaging, and development assistance strategies to support democratic alternatives to technology manufactured in China.³⁶⁸
 - Fostering the R&D necessary to provide alternatives will require public-private coordination or partnerships at an international level. (See Critical Area #2 for potential mechanisms)
 - Potential stakeholders for such a project include NSF, the National AI Research Institutes, DARPA, NIST, various EU Centres of Excellence, research institutions (such as the Johns Hopkins University Applied Physics Laboratory, the Massachusetts Institute of Technology Computer Science & AI Laboratory, and the Stanford Institute for Human-Centered AI), GPAI, and non-governmental organizations such as OpenMined.

Critical Area #4 - Exploring Ways to Facilitate Data Sharing

- *Objectives:*
 - Address legal and regulatory barriers to international collaborative work; explore bilateral and multilateral, general and specific approaches to enable data sharing, pooling, and storing consistent with privacy, security, and other fundamental values, including the viability of a Data Free Flow with Trust Agreement.
- *Methods to implement coordinated approaches to data sharing.*
 - **Development of shared data environments.** Development of pooled data storage centers, computational environments, and cloud and edge computing facilities to pool data from different sources for free use by credentialed researchers. An approach like this would prove particularly beneficial to improve data sharing among members to the Five Eyes alliance.

³⁶⁷ For more on democratic use of surveillance technologies, see Chapter 8: Upholding Democratic Values: Privacy, Civil Liberties, and Civil Rights in Uses of AI for National Security of this report.

³⁶⁸ Kara Frederick, *The Razor's Edge: Liberalizing the Digital Surveillance Ecosystem*, CNAS (Sept. 3, 2020), <https://www.cnas.org/publications/reports/the-razors-edge-liberalizing-the-digital-surveillance-ecosystem>.

- **Agreement on foundational data documentation, labelling, archiving, and data organization frameworks at international organizations.** Data agreements among members of alliances (such as NATO) or other international organizations would facilitate support to collaborative R&D endeavors, for example, ongoing efforts at the Organisation of Economic Co-operation and Development (OECD) AI Policy Observatory and Global Partnership on Artificial Intelligence (GPAI).
- **Agreements to share specific data sets with specified foreign partners.** Narrower in scope to the above two approaches, an agreement of this kind would allow researchers from different countries to access the same data sets for their respective projects. For example, in the context of COVID-19 and health care,³⁶⁹ countries would need to address data labelling, data storage, data anonymization, data security and other issues on a joint basis or through a pilot project.
 - This type of effort could also include joint projects with allies to anonymize³⁷⁰ high-impact datasets for specific research or initiatives (such as National Institutes of Health datasets and datasets maintained, for various purposes, by DOE, the U.S. Agency for International Development (USAID), the Food and Drug Administration, DARPA, IARPA, and the Department of State’s Center for Analytics).
 - Diplomatic effort is needed to resolve divergent views over what constitutes anonymized data, consent, and matters of public interest.
- **Ad hoc data sharing arrangements on bilateral or multilateral bases.** The ETC should explore the willingness of strategic allies and partners to engage in targeted, non-treaty data sharing arrangements. “Innovation sandbox” arrangements may be designed to facilitate specific challenges across all domains—security, health, disinformation, environmental resilience, and so on.
- **A multilateral data sharing agreement founded on trust.** The ETC should lead an effort to create a formal, potentially treaty-based approach to data sharing, pooling, and storing with like-minded governments modeled on the data free flow with trust (DFFT) concept introduced by Japan at the June 2019 G20 Summit. DFFT would permit the free flow of data between authorized parties upon meeting specific standards—including intellectual property (IP), privacy, and

³⁶⁹ See *OpenMined’s Efforts for the Coronavirus Pandemic: COVID Alert App, Private Set Interaction, A Differential Privacy Wrapper and Private Identity*, OpenMined (Apr. 1, 2020), <https://blog.openmined.org/openmineds-efforts-for-the-coronavirus-pandemic/>.

³⁷⁰ The U.S. and Europe should agree on a common definition for anonymized data to include a clearer understanding of what constitutes “consent” and “matters of public interest.”

cybersecurity protections.³⁷¹ The European Commission endorsed the DFFT concept in December 2020.³⁷²

- A *general* DFFT would require significant consideration of data protection, IP protection, privacy shield, and trade issues, both for the United States domestically and for foreign partners.
- A *specific* DFFT, on the other hand, focused on the free flow of data for particular purposes—such as facilitating pandemic response efforts—would have a greater chance of success and could be a model for targeted data sharing arrangements in other areas of shared interest.
- **Development of a secure AI research resource infrastructure.** A secure, cloud-based infrastructure would provide researchers from partnered and allied countries access to compute resources, diverse data-sets, and controlled environments to enable testing, for example of privacy preserving machine learning techniques. Participating like-minded governments would agree to and comply with common technical standards and norms³⁷³ and risk-based frameworks that ensure privacy, security, reliability, respect for the rule of law and other appropriate parameters.
 - Such an infrastructure could be developed bilaterally or multilaterally and could be a priority effort of the Commission’s proposed MAIRI. Research and academic institutions could support the MAIRI effort with appropriate technical and implementation assistance, while GPAI’s Data Governance Working Group could support the development and utilization of engineering best practices.

Critical Area #5 - Promoting and Protecting Innovation

- *Objectives:*
 - Develop an allied strategy to align and develop regulatory and legal regimes in areas critical to fostering domestic and international innovation. These areas include: export controls, investment screening, supply chain assurance, emerging technology investment, trade policy, intellectual property, technology transfer, and research protection.
 - Achieving such a strategy will require an integrated approach among allies and partners, leveraging our full technology toolkit, upgrading capabilities and where necessary developing new ones to counter threats. These efforts will require a

³⁷¹ Remarks by Angel Gurría, OECD Secretary General, delivered at the 2019 G20 Leaders’ Summer - Digital (AI, data governance, digital trade, taxation) (June 28, 2019), <https://www.oecd.org/g20/summits/osaka/2019-g20-leaders-summit-digital-osaka-june-2019.htm>.

³⁷² *A New EU-US Agenda for Global Change*, European Commission (Dec. 2, 2020), https://ec.europa.eu/info/sites/info/files/joint-communication-eu-us-agenda_en.pdf.

³⁷³ The Commission’s *Key Considerations* and existing international principles could be leveraged, such as: the OECD Principles on AI; the OECD Guidelines on the Protection of Privacy and Transborder Flows of Personal Data; the OECD Recommendation on Digital Security of Critical Activities; the forthcoming OECD Principles on Trusted Government Access to Data, among others.

coordinated strategic coordination plan to raise allied public awareness on issues such as technology transfer risks.

- *Export Controls & Investment Screening*
 - The ETC should explore coordinated approaches to export controls and investment screening. Cooperation in these areas is critical to ensure that like-minded nations have the authority to unilaterally institute export controls and block predatory investments that present risks to national and international security.
 - The Commission recommends in Chapter 14 of this report that the United States engage with allies and partners on legal reforms to (a) implement a coordinated approach to AI-related export controls and (b) enhance investment screening procedures and enforcement.³⁷⁴
 - The Commission has also recommended as part of Chapter 15's Blueprint for Action, that the United States should engage with allies and partners to align policy guidance on exports as part of the International Digital Democracy Initiative (IDDI) to promote technologies that comport with shared values and support free and open societies.³⁷⁵
 - As detailed in Chapter 14 of this report, export control priorities should include targeted, high-end semiconductor manufacturing equipment (SME) components needed to produce chips at the 16nm node and below. Additionally, states should explore implementing targeted end-use and end-user controls on specific high-end, AI-specialized chips to prevent their use in human rights violations.³⁷⁶
 - Consideration should be given to appropriate economic incentives to support alignment on export control and investment screening.
 - The ETC should also pursue robust collaboration on foreign S&T and investment flow monitoring—to include open-source intelligence—to utilize early warning indicators related to strategic acquisition risks. Further, ETC partners must share best practices to monitor smaller transactions that attempt to skirt existing controls.

³⁷⁴ See Chapter 14 of this report and the associated Blueprint for Action for additional details on the Commission's recommendations regarding aligning allied export control and investment screening regimes. Within the U.S. government, the Departments of State and Commerce, on export controls, and the Departments of State and the Treasury, on investment screening, have already begun such work.

³⁷⁵ See the Blueprint for Action associated with Chapter 15 of this report.

³⁷⁶ See *Second Quarter Recommendations*, NSCAI at 63-67 (July 2020), <https://www.nsc.ai.gov/previous-reports/>. In particular, the United States, the Netherlands, and Japan should coordinate export controls on extreme ultraviolet and ArF immersion lithography tools, as doing so would limit the ability of China and other competitors to develop the high-end microelectronics that are increasingly essential for AI. For additional details on the Commission's recommendations regarding export controls on semiconductor manufacturing equipment, see Chapter 14 of this report.

- *Supply Chain Assurance*
 - Leadership of the United States and its allies and partners in emerging technologies is dependent on components sourced from strategic competitors or regions with significant geopolitical risk.
 - The semiconductor manufacturing industry is a prime example of an industry that is critical to U.S. and allied security, but which is heavily concentrated in specific geographic regions and is therefore susceptible to supply-chain shocks, particularly in the event of a crisis.³⁷⁷
 - The ETC should conduct a supply chain assessment and make recommendations on integrated, multilateral approaches to coordinating critical technology components to enhance international security while reducing collective dependence on strategic competitors.³⁷⁸
 - The ETC should also develop a strategic plan to fund key chokepoint technologies and next-generation materials, approaches, and prototyping capabilities at discovery, manufacturing, and applied scales.³⁷⁹
- *Emerging Technology Investments*
 - Likewise, investments in emerging technologies require coordinated action. 5G presents a test case for the challenges of international and multilateral coordination. The United States and partners have cooperated on developing alternatives to Chinese 5G infrastructure multilaterally and bilaterally.
 - The Commission offered recommendations regarding steps to promote domestic development of 5G technology in its *First Quarter Recommendations* and urged the United States to continue to work closely with key allies and partners on both constructive 5G technical solutions, and to ensure that global 5G networks are safe and secure.³⁸⁰ Chapter 16 of this report details steps to promote domestic development of biotechnology, 5G, quantum computing, autonomy and robotics, advanced manufacturing, and energy systems, while Chapter 13 details steps to cultivate domestic innovation in microelectronics research and manufacturing.³⁸¹ The United States may engage key allies and partners on these technologies.
 - The ETC can serve as a forum to explore these issues in a coordinated manner.

³⁷⁷ See Chapter 13 for additional details and recommendations on the microelectronics supply chain.

³⁷⁸ See Chapters 3 and 14 of this report.

³⁷⁹ See *Second Quarter Recommendations*, NSCAI at 48 (July 2020), <https://www.nscai.gov/previous-reports>; Andrew Imbrie et al., *Agile Alliances: How the United States and its Allies Can Deliver a Democratic Way of AI*, Center for Security and Emerging Technology at 16-17 (Feb. 2020), <https://cset.georgetown.edu/research/agile-alliances/>; Andrew Imbrie, et al., *The Question of Comparative Advantage in Artificial Intelligence: Enduring Strengths and Emerging Challenges for the United States*, Center for Security and Emerging Technology at 33 (Jan. 2020), <https://cset.georgetown.edu/wp-content/uploads/CSET-The-Question-of-Comparative-Advantage-in-Artificial-Intelligence-1.pdf>.

³⁸⁰ *First Quarter Recommendations*, NSCAI at 45 (Mar. 2020), <https://www.nscai.gov/previous-reports/>.

³⁸¹ See Chapters 13 and 16 of this report.

- *Trade Policy*
 - Trade policy is a key lever for the United States and foreign governments to promote an innovation environment. The ETC should consider coordinated approaches to trade policy to further innovation and strengthen national and international security.
- *Intellectual Property*
 - Intellectual property rights and regimes are critical to innovation in AI and emerging technologies. The ETC should explore coordinated approaches to IP that could inform a mutual agenda with the World Intellectual Property Organization’s (WIPO) Conversation on AI and Intellectual Property, IP5,³⁸² and forums with broader mandates.
 - *Coordination on assistance to nations in developing strong and aligned IP regimes.* The ETC can assist the United States and partners in prioritizing assistance to nations in improving their IP regimes to help facilitate innovation while deterring IP theft. A more focused approach, through IP5 and WIPO, may prove more impactful in scope and could help to harmonize efforts to shore up IP with respect to identifiable international challenges.
 - The United States should engage with key allies and partners to align on critical aspects of IP, including patent eligibility for AI and associated technologies, countering China’s narrative on winning the innovation competition, IP contractual ecosystem impediments to international collaboration, IP protections for data, and the over-declaration of “standard essential” patents and other efforts to efforts by countries to exploit standards-setting and licensing processes.³⁸³
 - These are among a set of ten critical IP considerations that the Commission proposes to guide U.S. efforts to reform IP policies and establish new IP regimes for AI and critical emerging technologies in order to protect and promote national security, innovation, and technology competitiveness.³⁸⁴
 - *Coordinated efforts to stop IP theft and counter cyber espionage.* IP theft remains a global concern. With a goal of protecting the economic viability of AI innovation and emerging technologies, the ETC should identify methods to strengthen the international framework for addressing the export of counterfeit goods, theft of IP technology, forced technology transfers of foreign innovation, and cyber espionage.

³⁸² “IP5” is the name of the forum of the world’s five largest IP offices that was set up to improve the efficiency of the examination process for patents worldwide. See *About IP5 Co-Operation*, fiveIPOffices (last accessed Jan. 4, 2021), <https://www.fiveipoffices.org/about>.

³⁸³ See Chapter 12 of this report and its associated Blueprint for Action.

³⁸⁴ See Chapter 12 of this report and its associated Blueprint for Action.

- *Research and Cyber Protections*
 - **Promoting multilateral responses to research integrity and security.** As the Commission has proposed, the United States should coordinate action with allies and partners in developing multilateral responses to challenges to research integrity and security posed by PLA-affiliated individuals and entities and to promote a commitment to open fundamental research.³⁸⁵
 - A public-private research security clearing house that enables sharing of open source information, data-driven assessments, decision support resources, and education and training resources could strengthen this effort.³⁸⁶
 - **Promoting multilateral efforts to mitigate proliferating cyber vulnerabilities and develop AI-enabled defenses against cyber attacks.** As the Commission has proposed, the United States must prepare for AI-enabled cyber conflict. The United States should explore coordinating and joint efforts with key allies and partners.³⁸⁷

Critical Area #6 - Developing AI-Related Talent

- *Objectives:*
 - Cooperative efforts to enable government, military, academic, and private-sector talent exchanges and address challenges posed by immigration and visa restrictions; development of joint AI and digital training and workforce development programs.
- *Methods for furthering talent development globally.* The ETC should explore methods for achieving objectives, including the following:
 - **Creating new models for international talent exchanges.** International talent exchanges are powerful tools to further AI alignment, cross-pollinate ideas, and build AI-related skills and capabilities. In developing new approaches to talent exchanges, the ETC should consider:
 - Military officer exchanges to improve AI deployment and interoperability, including among NATO, JAIC, DoD, and foreign defense ministries and militaries;
 - Analogous training and exchanges needed for U.S. and allied diplomats and development experts;

³⁸⁵ See Chapter 10 of this report.

³⁸⁶ This approach has been recommended by Melissa Flagg and Zachary Arnold. See Melissa Flagg & Zachary Arnold, A New Institutional Approach to Research Security in the United States Defending a Diverse R&D Ecosystem, Center for Security and Emerging Technology (Jan. 2021).

<https://cset.georgetown.edu/research/a-new-institutional-approach-to-research-security-in-the-united-states/>.

³⁸⁷ See Chapter 1 and its associated Blueprint for Action on preparing for AI-enabled cyber conflict.

- Government-to-government exchanges of AI experts to assist in building tech and ethical expertise; exchanges to benefit industry-led multilateral and multi-stakeholder efforts like SDOs, GPAI, OECD and influence paths taken by partners;
- Talent exchanges and secondments in industry and academia (both international industry-industry or academia-academia talent exchanges as well as government-industry/academia).
- Leveraging research centers such as the proposed MAIRI to enable cross-border collaboration and talent exchanges.
- **Coordinating AI training development programs and sharing of best practices** for government training and broader AI education programs (including in secondary schools and universities to include computer science teaching and curriculum development).
 - The ETC should explore methods for non-EU partner nations to coordinate on the “Artificial Intelligence and Analytics” in the EU’s Digital Education Plan.

Critical Area #7 - International Digital Democracy Initiative

- The Chapter 15 Blueprint for Action details the Commission’s recommendations for coordinating foreign assistance, investment, and financing through the **International Digital Democracy Initiative**.

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Chapter 16: Associated Technologies

Blueprint for Action

Recognizing that leadership in artificial intelligence (AI) relies on leadership across a suite of emerging technologies, the United States must prioritize the research and development (R&D), application, and adoption of not just AI, but the technologies that enable it and are enabled by it. This process should be based on a careful analysis of the national security threats and opportunities at the intersection of AI and its associated technologies. If the U.S. government fails to adopt a more strategic approach to protecting and promoting U.S. advantages in these areas, it risks jeopardizing the country’s technological leadership, economic prosperity, and national security.

In accordance with its mandate to consider both AI and “associated technologies,” the Commission identifies and proposes steps to maintain U.S. leadership across the spectrum of technologies it believes are most critical to U.S. national competitiveness. The Commission then offers specific recommendations on how the United States can proactively address the novel national security threats and opportunities posed by three technologies in particular: biotechnology, quantum computing, and 5G telecommunications.³⁸⁸ Finally, the Commission expands its analysis to include recommendations on a broader set of emerging technologies critical to U.S. national competitiveness.

Technologies Critical to U.S. National Competitiveness

The Commission has identified eight technologies and related platforms that are key to U.S. leadership. Two of these technologies—AI and microelectronics—are addressed elsewhere in this report. The remaining six—biotechnology, quantum computing, 5G and advanced networking, autonomy and robotics, advanced and additive manufacturing, and energy systems—are covered below. These recommendations build on the Commission’s previous work by providing actions the U.S. government could take to promote overall U.S. leadership and long-term competitiveness across the constellation of emerging technologies.

Recommendation: Identify and Prioritize Technologies Central to National Competitiveness.

To date, there is no whole-of-government consensus for which emerging technologies are most critical to long-term strategic competitiveness and whose development must be prioritized. Several government agencies have made independent attempts to define such a list: the 2018 National Defense Strategy,³⁸⁹ the list of “critical emerging technologies” produced by the Department of Defense in response to Section 1793 of the FY 2019 National Defense

³⁸⁸ The Commission identified these as essential to overall U.S. technological leadership in its 2019 Interim Report. See *Interim Report*, NSCAI at 31 (Nov. 2019), <https://www.nscai.gov/previous-reports/>.

³⁸⁹ *Summary of the 2018 National Defense Strategy of the United States of America*, U.S. Department of Defense at 3 (2018), <https://dod.defense.gov/Portals/1/Documents/pubs/2018-National-Defense-Strategy-Summary.pdf>.

Authorization Act (NDAA),³⁹⁰ the Department of Commerce’s 2018 Advance Notice of Proposed Rulemaking (ANPRM) of controls on certain emerging technologies,³⁹¹ the report by the President's Council of Advisors on Science and Technology titled *Recommendations for Strengthening American Leadership in Industries of the Future* from 2020,³⁹² and the bill introduced by Senator Chuck Schumer in the 116th Congress with seven bipartisan co-sponsors titled the “Endless Frontier Act.”³⁹³ Additionally, the White House published the *National Strategy for Critical and Emerging Technologies* in October 2020, which included a list of critical and emerging technologies.³⁹⁴ However, this document does not explain why each of these technologies are essential to U.S. national competitiveness, nor does it include specific implementation plans for promoting their development and protecting U.S. advantages in each.

These lists have substantial overlap, but no two lists are the same and no single list is authoritative. Consequently, there is no whole-of-government consensus, and certainly no national consensus, of which technologies are critical to U.S. national competitiveness, making it more difficult for the U.S. government to marshal private sector investment, for legislators to prioritize funding, and for U.S. government agencies to coordinate technology protection and promotion. There is also no list around which the White House can organize a national technology strategy and no coordinated mechanism within the U.S. government to support financing of these priorities when there are market failures and private sector financing is insufficient.

Actions for the Executive Office of the President:

- **Define and prioritize the key emerging technologies in which U.S. leadership is essential.**
 - The Executive Office of the President, in consultation with departments and agencies, should publish a single, authoritative list of technologies and sectors which are key to overall U.S. competitiveness, along with detailed implementation plans for each to ensure long-term U.S. leadership.
 - The implementation plans should identify specific subcomponents of each technology that are most important, key choke points where competitors could be blocked with minimal impact on U.S. industry, and where additional resources are needed. These plans should include specific steps to promote domestic industry, ensure supply chain resiliency, and protect key technologies from competitors. This list of technologies and the

³⁹⁰ *Fiscal Year 2019 Industrial Capabilities: Report to Congress*, U.S. Department of Defense at 132 (June 23, 2020), <https://www.businessdefense.gov/Portals/51/Documents/Resources/USA000954-20%20RPT%20Subj%20FY19%20ICR%2007092020.pdf?ver=2020-07-10-124452-180>.

³⁹¹ 83 Fed. Reg. 58201, *Review of Controls for Certain Technologies*, U.S. Department of Commerce: Bureau of Industry and Security (Nov. 19, 2018), <https://www.federalregister.gov/documents/2018/11/19/2018-25221/review-of-controls-for-certain-emerging-technologies>.

³⁹² *Recommendations for Strengthening American Leadership in Industries of the Future*, President’s Council of Advisors on Science and Technology (June 2020), https://science.osti.gov/-/media/ /pdf/about/pcast/202006/PCAST_June_2020_Report.pdf.

³⁹³ S. 3832, 116th Cong. (2020), <https://www.congress.gov/bill/116th-congress/senate-bill/3832>.

³⁹⁴ *National Strategy for Critical and Emerging Technologies*, The White House at A-1 (Oct. 2020), <https://trumpwhitehouse.archives.gov/wp-content/uploads/2020/10/National-Strategy-for-CET.pdf>.

associated implementation plans will form the core of a National Technology Strategy, as referenced in Chapter 9 of this report.

- The creation and maintenance of such a list and implementation plans will help produce a national consensus regarding which industries are most important in the emerging techno-economic competition. The result will be an important message to Congress regarding where the country must prioritize and expend resources, as well as a powerful demand signal to industry. The figure below includes eight technologies that the Commission recommends be considered for the list.

Existing U.S. Government Lists of Critical Technologies						
NSCAI-Proposed Critical Technology List	2018 National Defense Strategy	DoD List of Critical Emerging Technologies	Commerce ANPRM on Emerging Technologies	PCAST List of Industries of the Future	S.3832 - Endless Frontier Act	WH Nat Strategy for C&ET
Artificial Intelligence	✓	✓	✓	✓	✓	✓
Biotechnology	✓	✓	✓	✓	✓	✓
Quantum Computing		✓	✓	✓	✓	✓
Semiconductors and Advanced Hardware	✓	✓	✓		✓	✓
Robotics and Autonomy	✓	✓	✓		✓	✓
Advanced Telecoms / 5G		✓		✓	✓	✓
Advanced Manufacturing			✓	✓	✓	✓
Energy Technology	✓	✓			✓	✓

- **Expand the loan authority of the Development Finance Corporation to include domestic industrial base capabilities supporting key emerging technologies.**

- The President should issue an executive order which expands the loan authority of the U.S. International Development Finance Corporation (DFC) to include domestic industrial base capabilities related to any of the aforementioned technologies that are identified by the Executive Office of the President as key to overall U.S. competitiveness.
 - Specifically, the executive order should delegate authority under Title III of the Defense Production Act to the DFC to issue loans that “create, maintain, protect, expand, or restore domestic industrial base capabilities”

supporting the aforementioned list of technologies, or “the resiliency of relevant domestic supply chains.” This new authority should be of indefinite duration.

- This action would build off of Executive Order 13922, which expanded similar domestic loan authorities to DFC related to industries supporting “the national response and recovery to the COVID-19 outbreak” until 2022.³⁹⁵
- Expanding the domestic authorities of the DFC as it relates to critical technologies will help the government support key platforms and projects which are critical to future U.S. national security and economic competitiveness but lack sufficient private sector capital.
 - The DFC should coordinate with the Technology Competitiveness Council recommended in Chapter 9 of this report to identify specific platforms which are most in need of such financing.

Ensuring U.S. Leadership in Biotechnology

The combination of advances in AI and biology have the potential to reshape the global economy for the next century. Progress in genetic sequencing has given researchers the ability to read the “code of life.” Given the significant quantity of data involved, AI will be essential to fully understanding how genetic code interacts with biological processes. Finally, advances in synthetic biology and genetic editing will give researchers the ability to manipulate this code to perform specific functions. Together, these techniques will enable transformational breakthroughs in biology and underpin most future scientific breakthroughs related to human health, agriculture, and climate science. The nation which is best able to simultaneously leverage both technologies will have substantial strategic advantages for the foreseeable future, potentially becoming a global leader in pharmaceuticals, reducing its reliance on foreign supply chains, and even ensure it has a healthier and more capable population. These technological breakthroughs will also cause the biotechnology sector to become a major driver of overall U.S. economic competitiveness.

Recommendation: Prioritize the development of an advanced biotechnology R&D ecosystem.

The United States must invest in key platforms which better position the U.S. academic and commercial biotech industry to benefit from AI-enabled advancements in biology. It should specifically look to support platforms which aggregate biodata, and specifically genetic data, in a secure manner in order to enhance the ability of U.S. researchers to utilize AI to facilitate breakthrough biotechnology research and innovation. Additionally, the United States should support efforts to expand the scope and sophistication of U.S. biofabrication capabilities to ensure it can keep pace with forthcoming research advancements. It should specifically support efforts to transform the biotechnology industry away from its current, vertically-integrated

³⁹⁵ Donald J. Trump, *Executive Order 13922: Delegating Authority Under the Defense Production Act to the Chief Executive Officer of the United States International Development Finance Corporation To Respond to the COVID-19 Outbreak*, The White House (May 14, 2020), <https://www.federalregister.gov/documents/2020/05/19/2020-10953/delegating-authority-under-the-defense-production-act-to-the-chief-executive-officer-of-the-united>.

models and encourage the development of multiple standardized, merchant biofabrication facilities. Doing so would expand access to advanced biofabrication tools among startups and laboratories by allowing firms to rapidly design new molecules and materials via the cloud and place immediate orders for fabrication.

Actions for Congress and the Department of Health and Human Services:

- **Fund and establish a world-class biobank for genetic data.**
 - Congress should fund efforts to build a world-class biobank within the National Institutes of Health (NIH). The current leading U.S. genetic database, GenBank, is under-funded, difficult to access, and poorly curated, particularly in comparison to other leading genetic databases such as the UK BioBank or the China National GeneBank. The entity should be securely and easily accessible by legitimate researchers, contain a wide variety of whole human, animal, and plant genomes including de-identified metadata about phenotypes, and aggregate other open and potentially even proprietary datasets for specialized uses. It must also include strong privacy protections for human genetic data. Creating and staffing such an entity would likely require a budget of approximately \$100 million per year, on top of up-front construction costs.³⁹⁶
- **Direct funding to support advanced biotech manufacturing initiatives through entities such as BARDA.**
 - The Department of Health and Human Services should direct funds to support advanced biotech manufacturing initiatives through entities such as the Biomedical Advanced Research and Development Authority (BARDA), and Congress should prioritize such initiatives in future health-related spending bills. This could take the form of financial incentives for advanced biotech manufacturing firms focused on sophisticated, flexible, cloud-based fabrication, or R&D funding to support advanced manufacturing techniques.

Recommendation: Prioritize Advanced Biotechnology Capabilities as Imperative for National Security and Economic Competitiveness.

The growing importance of biotechnology leadership to health, food, production, and science also makes it a national security imperative that the United States take proactive steps to facilitate long-term U.S. leadership in the field. Advancements in biotechnology will also create novel national security challenges, ranging from engineered pathogens to augmented competitor human physiological or mental capabilities. The United States currently is not postured to address such challenges, and biological threats have rarely been a priority issue for the U.S. national security community. The COVID-19 pandemic clearly illustrates that the United States

³⁹⁶ For comparison, the Chinese government provided approximately \$117 million in initial funding to the China National GeneBank for its construction and creation. See Zhuang Pinghui, *China Opens First National Gene Bank, Aiming to House Hundreds of Millions of Samples*, South China Morning Post (Sep. 22, 2016)

<https://www.scmp.com/news/china/article/2021623/chinas-noahs-ark-first-national-gene-bank-opens-shenzhen>

must think more broadly about national security threats than it has in the past, and that biological threats in particular have the potential to impose significant costs on U.S. society and security.

U.S. competitors see the potential for AI to spur new, transformational advances in biotechnology. China in particular is actively seeking global leadership in both fields, sees its AI and biotechnology strategies as mutually reinforcing, and believes the synergies between the two will translate into military advantage.³⁹⁷ China also faces fewer barriers to collecting, using, and combining human biological data given its disregard for individual privacy and bioethical principles. The global reach of China's genomics giant, BGI, poses similar threats in the biotechnology sector as Huawei does in the communications sector.

Actions for the Executive Office of the President:

- **Update the U.S. National Biodefense Strategy to include additional AI-enabled biological threats.**³⁹⁸
 - The National Security Council should update its *National Biodefense Strategy*, which currently only focuses on natural or engineered pathogens, to include a wider vision of biological threats.³⁹⁹ The strategy should specifically examine how AI could enable new biological advances which pose unique national security threats, such as human enhancement, and how U.S. competitors could utilize advantages in biotechnology or biodata as an instrument of national power. It should also specifically consider how AI could identify and counter the creation of advanced, engineered pathogens which target certain elements of the U.S. population or food supply. AI is facilitating a rapid evolution of the biotechnology field, and the U.S. biodefense strategy must evolve with it.
- **Direct departments and agencies to prioritize initiatives which promote U.S. biotechnology leadership.**
 - Directing departments and agencies to prioritize initiatives promoting U.S. biotechnology leadership would include aggressively promoting funding for basic research in biology, particularly applications of biology which utilize AI; focusing resources on forecasting how AI will enable future biotechnology breakthroughs; and continuing to cultivate talent both inside and outside the government, as well as commercial activity at the nexus of AI and biology. This will require an entity which is empowered to coordinate across the economic, technological, and security spheres, such as the Commission's recommended Technology Competitiveness Council.⁴⁰⁰

Recommendation: Publicly Highlight BGI's Links to the Chinese Government.

³⁹⁷ Elsa Kania, *Minds at War: China's Pursuit of Military Advantage through Cognitive Science and Biotechnology*, Prism (Jan. 2020), https://ndupress.ndu.edu/Portals/68/Documents/prism/prism_8-3/prism_8-3_Kania_82-101.pdf.

³⁹⁸ This recommendation is included in Chapter 1 of this report.

³⁹⁹ *National Biodefense Strategy*, The White House (2018), <https://trumpwhitehouse.archives.gov/wp-content/uploads/2018/09/National-Biodefense-Strategy.pdf>.

⁴⁰⁰ See Chapter 9 of this report for additional details on the proposed Technology Competitiveness Council.

BGI is China's de facto national champion in genetic sequencing and research, and is among the world leaders in DNA sequencing. It has research affiliations with multiple U.S. universities, including the University of Washington and Washington State University.⁴⁰¹ BGI has also benefited from substantial support from the Chinese government, as well as its 2013 acquisition of a competing U.S. firm, Complete Genomics.⁴⁰² There are indications that BGI's links with the Chinese government may run deeper than it publicly claims, as it built and operates China National GeneBank, the Chinese government's national genetic database, and has used PLA-owned supercomputers to process genetic information.⁴⁰³ Chinese diplomats have pushed BGI-built COVID-19 testing kits, including in the United States, and by August 2020 BGI had "sold 35 million rapid COVID-19 testing kits to 180 countries, and built 58 labs in 18 countries."⁴⁰⁴

BGI may be serving, wittingly or unwittingly, as a global collection mechanism for Chinese government genetic databases, providing China with greater raw numbers and diversity of human genome samples as well as access to sensitive personal information about key individuals around the world. The highest levels of the United States government should publicly state these concerns so as to raise awareness among the U.S. commercial and academic biotechnology communities, as well as U.S. allies, many of which currently have partnerships or business dealings with BGI.

Action for the Department of State:

- **Launch a strategic communications campaign to publicly highlight the links between the Chinese government and BGI.**
 - The Secretary of State should personally voice concern about BGI's ties to the Chinese government, and instruct the Department to conduct a strategic communications campaign to highlight those links and warn of the dangers of the Chinese government obtaining personal genetic information via BGI. The Department should also warn BGI and the Chinese government that it will closely monitor BGI's activities, and that should BGI be utilized as a mass DNA collection apparatus for the Chinese government it could face additional U.S. regulatory action.

⁴⁰¹ See, e.g., *BGI & US Collaborate on Precision Medicine Development*, UW Medicine (May 10, 2016), <https://newsroom.uw.edu/story/bgi-uw-collaborate-precision-medicine-development>.

⁴⁰² In 2010, BGI received a \$1.5 billion loan from the state-run China Development Bank. The precise extent of government subsidies to BGI are unknown, but likely substantial. See Kirsty Needham, *Special Report: COVID Opens New Doors for China's Gene Giant*, Reuters (Aug. 5, 2020), <https://www.reuters.com/article/us-health-%20coronavirus-bgi-specialreport/special-report-covid-opens-new-doors-for-chinas-gene-giant-idUSKCN2511CE>; see also Antonio Regaldo, *China's BGI Says It Can Sequence a Genome for Just \$100*, MIT Technology Review (Feb. 26, 2020), <https://www.technologyreview.com/2020/02/26/905658/china-bgi-100-dollar-genome/>.

⁴⁰³ *China National Genebank Officially Opens*, BGI (Sept. 22, 2016), <https://www.bgi.com/us/company/careers/china-national-genebank-officially-opens/>.

⁴⁰⁴ See Kirsty Needham, *Special Report: COVID Opens New Doors for China's Gene Giant*, Reuters (Aug. 5, 2020), <https://www.reuters.com/article/us-health-coronavirus-bgi-specialreport/special-report-covid-opens-new-doors-for-chinas-gene-giant-idUSKCN2511CE>; see also Jeanne Whalen & Elizabeth Dvoskin, *California Rejected Chinese Company's Push to Help with Coronavirus Testing. Was That the Right Move?*, Washington Post (July 2, 2020), <https://www.washingtonpost.com/business/2020/07/02/china-bgi-california-testing/>.

Recommendation: Pursue Global Cooperation on Smart Disease Monitoring.

While pivoting to a more competitive national approach toward biotechnology policy, the United States should also pursue efforts to enhance global cooperation on disease monitoring. By pooling existing open-source health-related data with improved early warning signals and data on zoonotic spillovers and transmission of novel viruses, governments will be better postured to use AI to predict and contain future pandemics. Combining increased transparency and data sharing on disease outbreaks with AI tools—which can enhance early outbreak detection and contribute to real-time disease monitoring—could provide substantial benefit for global public health if all countries, including China, participated in good faith.⁴⁰⁵

Action for the Departments of State and Health and Human Services:

- **Support multilateral efforts to promote smart disease monitoring.**
 - The Departments of State and Health and Human Services should lead and support multilateral efforts to promote smart disease monitoring. In particular, the United States should pursue efforts to integrate and standardize international health-related datasets and combine them with global data about zoonotic spillovers to allow for the utilization of AI technologies to create shared, predictive, global disease monitoring tools.

Ensuring U.S. Leadership in Quantum Computing

Quantum computing has the potential to create new national security threats and opportunities by enhancing the speed and precision of existing AI systems and creating new capabilities that could fundamentally alter the strategic environment. For example, quantum computers may be able to more efficiently optimize logistics for the military or discover new materials for weapons systems.⁴⁰⁶ Quantum sensors and communications are also poised to revolutionize the collection and transfer of sensitive information, which directly affects how AI is trained and deployed in national security use cases.⁴⁰⁷ Failure to step up investment in the research and development of materials and components for quantum computers, open-source software tools, and hybrid quantum-classical algorithms that leverage noisy intermediate-scale quantum computers may leave the United States vulnerable to strategic surprise on behalf of competitors.⁴⁰⁸

⁴⁰⁵ See Chapters 9 and 15 of this report for additional information on cooperation on issues at the intersection of AI and global health.

⁴⁰⁶ Pontus Vikstål, et al., *Applying the Quantum Approximate Optimization Algorithm to the Tail-Assignment Problem*, *Physical Review Applied* Vol 14, Iss. 3 (Sept. 3, 2020), <https://doi.org/10.1103/PhysRevApplied.14.034009>; He Ma, et al., *Quantum Simulations of Materials on Near-term Quantum Computers*, *npj Computational Materials* (July 2, 2020), <https://doi.org/10.1038/s41524-020-00353-z>.

⁴⁰⁷ C. L. Degen, et al., *Quantum Sensing*, arXiv (June 7, 2017), <https://arxiv.org/pdf/1611.02427.pdf>; Juan Yin, et al., *Entanglement-based Secure Quantum Cryptography over 1,120 Kilometres*, *Nature* 582, 501–505 (June 15, 2020), <https://doi.org/10.1038/s41586-020-2401-y>.

⁴⁰⁸ In December 2020, a team of researchers in China demonstrated quantum advantage on a photonic quantum computer. See Han-Sen Zhong, et al., *Quantum Computational Advantage Using Photons*, *Science* (Dec. 18, 2020), <https://science.sciencemag.org/content/370/6523/1460>.

Recommendation: Transition from Basic Research to National Security Applications of Quantum Computing.

Although the United States is well-positioned to take advantage of its early success in the basic science of quantum computing, the United States Government must increase its focus on fielding national security applications or risk falling behind strategic competitors. Most notably, China has made significant investments in military applications of quantum computing in an attempt to offset U.S. strengths.⁴⁰⁹ The Department of Defense (DoD) is still refining its approach to rapidly transition commercial technologies from research to fielding in high-cost, hardware-intensive sectors such as quantum computing. In the long term, DoD should prioritize efforts to rapidly procure technology across its innovation offices, but this process could take several years of dedicated effort. In the interim, announcements of priority applications will help spur private sector investment and innovation in quantum computing despite the absence of an integrated technology procurement apparatus.⁴¹⁰

Action for the President:

- **The President should direct departments and agencies to announce priority use cases of quantum computers.**
 - The National Quantum Coordination Office (NQCO) should coordinate an effort by departments and agencies represented on the National Science and Technology Council (NSTC) Subcommittee on Quantum Information Science (QIS) to announce their priority use cases of quantum computers. By reflecting the combined views of federal entities engaging with the private sector, this would signal that a market for practical applications of quantum computing exists, set clear and specific goals for the private sector to pursue, and incentivize additional private investment. Some applications of quantum computers may be too sensitive to reveal publicly, but those which can be announced will provide direction to the private sector and facilitate the commercialization of quantum computers, which can then be applied to national security use cases.

Recommendation: Foster a Vibrant Domestic Quantum Fabrication Ecosystem.

Due to the strategic implications of quantum computing and its application to AI, the United States must take steps now to cement its long-term status as the global leader in the design and manufacturing of quantum processing units (QPUs). To avoid the situation in which the U.S. semiconductor industry currently finds itself, the United States must establish trusted and assured sources for critical materials and components of QPUs, ranging from manufacturing equipment to superconductors and dilution refrigerators.⁴¹¹ Although these materials and components may not yet represent choke points, they will inevitably become more specialized as the

⁴⁰⁹ Elsa B. Kania & John Costello, *Quantum Hegemony? China's Ambitions and the Challenge to U.S. Innovation Leadership*, CNAS (Sept. 12, 2018), <https://www.cnas.org/publications/reports/quantum-hegemony>.

⁴¹⁰ For additional information and NSCAI views on quantum computing, AI, and national security, see *Interim Report and Third Quarter Recommendations*, NSCAI at 154-163 (Oct. 2020), <https://www.nscai.gov/previous-reports/>.

⁴¹¹ *Applications of Quantum Technologies: Executive Summary*, Defense Science Board at C-1 (Oct. 2019), https://dsb.cto.mil/reports/2010s/DSB_QuantumTechnologies_Executive%20Summary_10.23.2019_SR.pdf.

manufacturing processes required to design and produce QPUs continue to advance. Rather than reshoring the entire supply chain for QPUs, the United States should work with its allies to develop a resilient network of suppliers for critical components that directly impact U.S. national security.

However, a secure supply chain is not sufficient to ensure U.S. leadership in quantum computing. To benefit from future breakthroughs in the field, the United States must create a robust domestic ecosystem for the research, development, and application of quantum computers that attracts top-tier talent from around the world.⁴¹² The United States Government should offer incentives for the research and development of quantum computers and their components while simultaneously creating demand for national security applications of quantum technologies. The Quantum Economic Development Consortium (QED-C), proposed in the National Quantum Initiative (NQI) Act of 2018, is an important step towards extending U.S. leadership in next-generation computer hardware for years to come.⁴¹³

Action for Congress:

- **Enact a package of provisions that incentivizes the domestic design and manufacturing of quantum computers and their constituent materials.**
 - A tax credit for expenditures made in the United States on research and development, manufacturing equipment, and workforce training related to the development of quantum technologies is a necessary, albeit not sufficient, step to maintain U.S. competitiveness in this area. This provision could be modeled on the Alternative Simplified Credit (ASC), which provides a credit of fourteen percent of expenditures on research and development in excess of fifty percent of base period expenditures. To help startups on the cutting edge of research and development access funding that allows them to scale, the United States Government should also provide loan guarantees and equity financing.

⁴¹² Dario Gil, *How to Ensure the U.S.'s Quantum Future*, Scientific American (Aug. 20, 2020), <https://www.scientificamerican.com/article/how-to-ensure-the-uss-quantum-future/>.

⁴¹³ The bipartisan National Quantum Initiative Act of 2018 prompted a series of steps that establish quantum computing as a strategic priority for the United States. The Department of Energy (DoE) announced \$625 million to establish five Quantum Information Science research centers over five years led by the national laboratories. The National Science Foundation (NSF) announced \$75 million to create three Quantum Leap Challenge Institutes over the same period. Lastly, the President's FY 2021 Budget recommended doubling federal investment levels in quantum technologies by 2022. This continuing investment is necessary to determine the full potential of quantum computing and maintain the United States' position of leadership in next-generation computer hardware. For more details, see Pub. L. 115-368, National Quantum Initiative Act, 115th Cong. (2018), <https://www.congress.gov/bill/115th-congress/house-bill/6227>; *Department of Energy Announces \$625 Million for New Quantum Centers*, U.S. Department of Energy (Jan. 10, 2020), <https://www.energy.gov/articles/department-energy-announces-625-million-new-quantum-centers>; *NSF Establishes 3 New Institutes to Address Critical Challenges in Quantum Information Science*, National Science Foundation (July 21, 2020), https://www.nsf.gov/news/special_reports/announcements/072120.jsp; *Recommendations for Strengthening American Leadership in Industries of the Future*, The President's Council of Advisors on Science and Technology at 13 (June 2020), https://science.osti.gov/-/media/ /pdf/about/pcast/202006/PCAST_June_2020_Report.pdf?la=en&hash=019A4F17C79FDEE5005C51D3D6CAC81FB31E3ABC.

Recommendation: Make Quantum Computing Accessible to Researchers via the National AI Research Resource.

Despite recent advances in the fields of quantum hardware and software, fault-tolerant quantum computers (FTQCs) capable of performing general-purpose tasks are unlikely to replace classical computers anytime soon. In the near-term, the United States should invest in noisy intermediate-scale quantum (NISQ) computers that are capable of deriving probabilistic solutions from imperfect qubits.⁴¹⁴ Hybrid quantum-classical techniques have also shown promise, whereby classical computers delegate certain tasks to purpose-built quantum devices within the same workflow. However, resources suitable for developing this type of software are not readily accessible.⁴¹⁵ By making classical and quantum computers available in the same workflow, the United States Government would lower barriers to innovation for start-ups in the quantum computing space and attract top-tier talent from around the world. The resulting public-private partnerships would also encourage the commercialization of quantum computers and help the United States Government adopt those products for national security use cases.

Action for the Executive Branch:

- **Make classical and quantum computers available in the same workflow via the National AI Research Resource.**
 - By providing access to both classical and quantum computers via the National AI Research Resource (NAIRR), which the Commission recommended establishing in its *First Quarter Recommendations* and describes in greater detail in Chapter 11 of this report,⁴¹⁶ the United States Government would help researchers from industry, academia, and government build and test software tools and algorithms that leverage both classical and quantum computers in a hybrid fashion. These types of applications are likely to be the nearest-term use case of quantum computers.

Ensuring U.S. Leadership in 5G Telecommunications

AI systems require high-fidelity sensing as well as fast, safe, and secure networks. It is a national security imperative for the U.S. military and the nation as a whole to have access to a powerful 5G network to enable future AI capabilities and ensure the network is trusted. The United States

⁴¹⁴ John Preskill, *Quantum Computing in the NISQ Era and Beyond* arXiv at 4, 14 (July 30, 2018), <https://arxiv.org/pdf/1801.00862.pdf>.

⁴¹⁵ The Department of Energy and the Air Force offer access to commercial quantum capabilities, but this access is not widespread, nor is it focused on hybrid quantum-classical software development. See Adrian Cho, *After Years of Avoidance, Department of Energy Joins Quest to Develop Quantum Computers*, Science (Jan. 10, 2018), <https://www.sciencemag.org/news/2018/01/after-years-avoidance-department-energy-joins-quest-develop-quantum-computers>; *Air Force Research Laboratory to Join IBM Q Network as First DOD-led IBM Q Hub*, Wright-Patterson AFB (Aug. 2, 2019), <https://www.wpafb.af mil/News/Article-Display/Article/1924271/air-force-research-laboratory-to-join-ibm-q-network-as-first-dod-led-ibm-q-hub/>.

⁴¹⁶ See *First Quarter Recommendations*, NSCAI at 12-13 (Mar. 2020), <https://www.nscai.gov/previous-reports/>. In the FY 2021 NDAA, Congress took the first step towards implementing the Commission's First Quarter recommendation by creating a task force to develop a road map for the NAIRR. See Pub. L. 116-283, William M. (Mac) Thornberry National Defense Authorization Act for Fiscal Year 2021, 134 Stat. 3388 (2021). In Chapter 11, the Commission urges Congress to authorize and appropriate the funds necessary to carry out the task force's road map immediately.

must preserve this access and trust while building out commercial 5G networks domestically and internationally.

Recommendation: Accelerate U.S. 5G Deployment through Spectrum Sharing

The slow rollout of 5G networks in the United States compared to China risks undermining U.S. advances in AI, both in the government and the private sector.⁴¹⁷ The sub-6 GHz spectrum, sometimes referred to as the mid-band or the “goldilocks” band of spectrum, is the critical portion of the spectrum for both DoD and commercial 5G operations. Sub-6 GHz spectrum is critical for 5G civilian communications since it combines high data rates with good range and penetration. Within DoD, it is also already used by many radar and communication systems because it also combines high discrimination capability with long range operations.⁴¹⁸ In part due to its importance to military operations, DoD has retained exclusive access to significant portions of the mid-band spectrum, which limits commercial uses. Unfortunately, the lack of U.S. mid-band spectrum commercial availability is substantially slowing the deployment of 5G networks domestically. Given that sub-6 GHz is important for sensing using radar and civilian communications, spectrum sharing between DoD and the private sector is the ideal approach to enabling access for both purposes in a manner that balances national security and economic interests.⁴¹⁹

Several U.S. Government agencies are working to address this problem by developing spectrum sharing capabilities within the 3 to 6-GHz range. In 2015, the Federal Communications Commission (FCC) established the Citizens Broadband Radio Service (CBRS), the first U.S. spectrum sharing model.⁴²⁰ Since that time, the National Telecommunications and Information Administration (NTIA) has studied, and has collaborated with the DoD and FCC, on maximizing spectrum sharing capabilities.⁴²¹ The CBRS enables shared federal and non-federal use of the band. This work allows the U.S. Navy and non-government providers to share the 3550-3700 MHz band across three, dynamically-managed tiers: the Navy will maintain first priority access, followed by companies and organizations which purchase priority-access licenses, and finally companies and organizations that register at no cost. The FCC held its first auction for priority-access licenses for this band in July 2020, which raised over \$4.5 billion through the sale of 20,625 licenses.⁴²² This is a promising but modest start and these efforts must expand to a larger portion of the mid-band spectrum to be competitive with China. To achieve spectrum sharing at a competitive level will require technical analysis and engagement with industry. A comprehensive process will be critical to ensuring that DoD maintains access to spectrum essential for

⁴¹⁷ Dan Strumpf, *U.S. vs. China in 5G: The Battle Isn't Even Close*, Wall Street Journal (Nov. 9, 2020), <https://www.wsj.com/articles/u-s-vs-china-in-5g-the-battle-isnt-even-close-11604959200>.

⁴¹⁸ Dana Deasy, *Department of Defense Statement on Mid-Band Spectrum*, U.S. Department of Defense (Aug. 10, 2020), <https://www.defense.gov/Newsroom/Speeches/Speech/Article/2307288/departement-of-defense-statement-on-mid-band-spectrum>.

⁴¹⁹ Milo Medin & Gilman Louie, *The 5G Ecosystem: Risks & Opportunities for DoD*, Defense Innovation Board (Apr. 3, 2019), https://media.defense.gov/2019/Apr/03/2002109302/-1/-1/0/DIB_5G_STUDY_04.03.19.PDF.

⁴²⁰ *3.5 GHz Band Overview*, U.S. Federal Communications Commission (Apr. 23, 2020), <https://www.fcc.gov/wireless/bureau-divisions/mobility-division/35-ghz-band/35-ghz-band-overview>.

⁴²¹ Edward Drocella, et al., *Technical Feasibility of Sharing Federal Spectrum with Future Commercial Operations in the 3450-3550 MHz Band*, NTIA (Jan. 27, 2020), <https://www.ntia.gov/report/2020/technical-feasibility-sharing-federal-spectrum-future-commercial-operations-3450-3550>.

⁴²² See *Public Notice: Auction of Priority Access Licenses in the 3550-3650 MHz Band Closes*, FCC (Sept. 2, 2020), <https://docs.fcc.gov/public/attachments/DA-20-1009A1.pdf>.

operational effectiveness, while also broadening commercial access to spectrum for civilian 5G networks.⁴²³

Action for the NTIA, FCC, and DoD:

- **Expand spectrum sharing programs led by NTIA, FCC, and DoD starting with a one year 5G spectrum sharing demonstration program.**
 - The Commission urges NTIA, the FCC, and DoD to jointly expand spectrum-sharing programs such as the CBRS, and work to license additional sub-6GHz spectrum to wireless carriers and equipment makers for commercial 5G use. Sharing and licensing additional mid-band spectrum will ensure unrestricted DoD access in the event of an emergency while also opening up 5G for commercial use. However, current spectrum sharing capabilities must be further analyzed, tested, and demonstrated before they can be scaled. The Commission supports a one year demonstration program that includes NTIA, FCC, DoD and industry to assess the network's capabilities and its capacity to dynamically share spectrum between government and civilian users. If successful, such a network would be rapidly scaled with commercially available equipment.

Promote U.S. Leadership in Other Key Emerging Technologies

AI, microelectronics, biotechnology, quantum computing, and 5G telecommunications are not the only emerging technologies that will underpin U.S. national competitiveness in the twenty-first century. The Commission assesses the full spectrum of emerging technologies key to U.S. technological leadership extends further and includes autonomy and robotics, advanced manufacturing, and energy systems. The Commission therefore recommends several actions to ensure U.S. leadership in these additional key emerging technologies.⁴²⁴

Autonomy and Robotics

Autonomous systems that rely on robotics to execute tasks in the real world are being applied to everything from advanced manufacturing to warfighting.⁴²⁵ As AI continues to improve the ability of these systems to match or exceed human capabilities, the United States must position itself as a leading producer and adopter of robotic hardware and software for civilian and military use cases. The United States currently lags behind countries such as Japan and Korea on the manufacturing and installation of industrial robots and China has declared robotics as a core

⁴²³ In April 2019, the Defense Innovation Board issued a report which argued that the status quo of spectrum allocation is unsustainable and DoD must expand its sub-6GHz spectrum sharing operations to enable the United States to compete with China in 5G. Milo Medin & Gilman Louie, *The 5G Ecosystem: Risks & Opportunities for DoD*, Defense Innovation Board (Apr. 3, 2019), https://media.defense.gov/2019/Apr/03/2002109302/-1/-1/0/DIB_5G_STUDY_04.03.19.PDF. For additional information and views of the Commission on 5G, see *First Quarter Recommendations*, NSCAI at 54-57 (Mar. 2020), <https://www.nscai.gov/previous-reports/>.

⁴²⁴ Recommendations to ensure U.S. leadership in biotechnology, quantum computing, and 5G telecommunications can be found above. Recommendations pertaining to semiconductors and advanced computer hardware are covered in Chapter 13.

⁴²⁵ *Summer Study on Autonomy*, Defense Science Board (June 2016), <https://dsb.cto.mil/reports/2010s/DSBSS15.pdf>.

industry.⁴²⁶ As the United States reshores certain strategic supply chains and increases its reliance on autonomous systems, continued access to cutting-edge robotics will be a national security imperative.

Action for the National Institute of Standards and Technology:

- **Incentivize the development of world-class software platforms for robotic systems by U.S. firms.**
 - By designing the software platforms upon which core robotic capabilities are built, U.S. firms will be well positioned to shape the next wave of industrialization. The U.S. government should expand collaboration with industry on basic R&D, set international standards, and share data pertaining to robotic system development by expanding upon the work of the Intelligent Systems Division at the National Institute of Standards and Technology (NIST).⁴²⁷ The U.S. government should also incentivize the early adoption of robotic systems across the public and private sectors by creating markets in areas ripe for automation.⁴²⁸ These efforts will yield valuable data and experience in scaling automation and facilitate the application of robotics to adjacent sectors. A multipronged approach along these lines will position U.S. industry to compete more effectively in the market for robotic systems software, a strategically important area that is compatible with existing U.S. strengths.

Advanced Manufacturing

The ability to manufacture high-tech products domestically is critical to a nation's security and its economic productivity. The United States must strive to develop manufacturing capabilities in industries that are essential to crisis response or that would take too long to bring online in the event of a protracted conflict.⁴²⁹ Innovation also benefits from the co-location of firms engaged in technological design and those that produce finished products, which enables rapid feedback and continuous iteration on product design.⁴³⁰ This link is particularly important in the defense sector, where communication between researchers, designers, and manufacturers can help

⁴²⁶ China owns one fifth of the global supply of industrial robots, and sought to have 45% of its high-end robots be produced domestically by the end of 2020. See Johnny Williamson, *How Nations Around the World are Investing in Robotics Research*, The Manufacturer (June 10, 2020), <https://www.themanufacturer.com/articles/how-nations-around-the-world-are-investing-in-robotics-research/>.

⁴²⁷ *Intelligent Systems Division*, NIST (last accessed Feb. 2, 2021), <https://www.nist.gov/el/intelligent-systems-division-73500>.

⁴²⁸ For example, the U.S. Postal Service could scale its Autonomous Mobile Robot pilot program from twenty five sorting facilities to all sorting facilities by 2025. *Autonomous Mobile Robots and the Postal Service*, U.S. Postal Service Office of Inspector General (Apr. 9, 2018), <https://www.uspsoid.gov/sites/default/files/document-library-files/2019/RARC-WP-18-006.pdf>.

⁴²⁹ An E.O. 13806 report identifies 10 manufacturing risk archetypes. See *Assessing and Strengthening the Manufacturing and Defense Industrial Base and Supply Chain Resiliency of the United States*, U.S. Department of Defense (Sept. 2018), <https://media.defense.gov/2018/Oct/05/2002048904/-1/-1/1/ASSESSING-AND-STRENGTHENING-THE-MANUFACTURING-AND%20DEFENSE-INDUSTRIAL-BASE-AND-SUPPLY-CHAIN-RESILIENCY.PDF>.

⁴³⁰ *Strategy for American Leadership in Advanced Manufacturing*, National Science and Technology Council (Oct. 2018), <https://trumpwhitehouse.archives.gov/wp-content/uploads/2018/10/Advanced-Manufacturing-Strategic-Plan-2018.pdf>; Gregory Tassey, *Rationales and Mechanisms for Revitalizing US Manufacturing R&D Strategies*, NIST (Jan. 29, 2010), https://www.nist.gov/system/files/documents/2017/05/09/manufacturing_strategy_paper_0.pdf.

quickly transition a technology from the lab to the field. However, the United States has relinquished manufacturing leadership in high-tech industries that employ highly skilled workers to high-wage nations like Germany and Japan.⁴³¹ Meanwhile, China and other lower-wage nations are moving up the value chain from low-value manufacturing processes, such as assembly, to more sophisticated techniques.⁴³² Although the supply chain disruptions resulting from the COVID-19 pandemic may prompt the return of some manufacturing to the United States, the broader trend of offshoring the manufacturing of next-generation technologies appears likely to continue unless the U.S. government takes appropriate action.⁴³³

Action for the Department of Defense:

- **Accelerate additive manufacturing of legacy parts across the Department of Defense.**
 - Additive manufacturing and 3D printing have the potential to transform the manufacturing industry by enabling the rapid production of complex objects on demand and at the point of need.⁴³⁴ Although existing 3D printers cannot match the quality of advanced traditional techniques, AI has shown the potential to significantly improve the accuracy of 3D printing.⁴³⁵ The Department of Defense should proactively support the improvement of 3D printing by identifying all legacy parts in active weapon systems suited to production by additive manufacturing and 3D printers and commit to doing so by 2025.⁴³⁶

Energy Systems

Cheap and reliable access to energy is critical to U.S. national security. Although the United States is at the forefront of the exploration, extraction, and processing of oil and gas and possesses significant domestic reserves, China is by far and away the leading producer of renewable energy and is investing heavily in advanced energy storage technologies, such as batteries and their constituent materials.⁴³⁷ As the cost of intermittent renewable sources

⁴³¹ *Report to the President on Ensuring American Leadership in Advanced Manufacturing*, President's Council of Advisors on Science and Technology (June 2011), <https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/pcast-advanced-manufacturing-june2011.pdf>; *Advanced Manufacturing: A Snapshot of Priority Technology Areas Across the Federal Government*, National Science and Technology Council (Apr. 2016), https://www.manufacturing.gov/sites/default/files/2018-01/nstc_sam_technology_areas_snapshot.pdf.

⁴³² *Report to the President on Ensuring American Leadership in Advanced Manufacturing*, President's Council of Advisors on Science and Technology at 3 (June 2011), <https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/pcast-advanced-manufacturing-june2011.pdf>.

⁴³³ *Advanced Manufacturing: Innovation Institutes have Demonstrated Initial Accomplishments, but Challenges Remain in Measuring Performance and Ensuring Sustainability*, GAO-19-409 at 1 (May 23, 2019), <https://www.gao.gov/assets/700/699310.pdf>.

⁴³⁴ *Audit of the DoD's Use of Additive Manufacturing for Sustainment Parts*, U.S. Department of Defense Inspector General (Oct. 17, 2019), <https://media.defense.gov/2019/Oct/21/2002197659/-1/-1/1/DODIG-2020-003.PDF>.

⁴³⁵ Mark Anderson, 3D Print Jobs Are More Accurate With Machine Learning, IEEE Spectrum (Feb. 19, 2020), <https://spectrum.ieee.org/tech-talk/artificial-intelligence/machine-learning/3d-print-jobs-news-accurate-machine-learning>.

⁴³⁶ For instance, in August 2020, the Department of Defense printed the first metal part for a B-52 jet engine. See Kyle Mizokami, *The Old-School Engine That Powers the B-52 Gets a 3D-Printed Upgrade*, Popular Mechanics (Aug. 10, 2020), <https://www.popularmechanics.com/military/aviation/a33535790/air-force-3d-print-metal-part-turbofan-engine/>.

⁴³⁷ Robert Rapier, *Ten Countries That Dominate Fossil Fuel Production*, Forbes (July 14, 2019), <https://www.forbes.com/sites/rpapier/2019/07/14/ten-countries-that-dominate-fossil-fuel-production/>; *Country Rankings*,

continues to fall, the United States must commit to developing and deploying the next generation of energy storage devices, from long-duration stationary applications to battery packs for electric vehicles.

Action for Congress:

- **Fund the Department of Energy’s initiative to develop and domestically manufacture energy storage technologies to meet U.S. market demand by 2030.**
 - Improving the cost and energy density of storage technologies will drive progress in sectors ranging from electric vehicles to distributed energy generation. The Department of Energy (DoE) has set the ambitious goal of developing and domestically manufacturing storage technologies capable of meeting the entirety of U.S. market demand by 2030.⁴³⁸ Congress should fully fund the federal R&D needed to achieve the DoE’s Energy Storage Grand Challenge roadmap by 2030 and establish appropriate incentives for the commercialization of the resulting technologies.⁴³⁹

Further Consideration of Additional Technologies and Conclusion

While the Commission believes the eight emerging technologies discussed above and elsewhere in this report - AI, microelectronics, biotechnology, quantum computing, 5G telecommunications, autonomy and robotics, advanced manufacturing, and energy systems - will be crucial to future national competitiveness, this list is by no means exhaustive. Other emerging technologies and platforms, such as advancements in financial technology and space systems, will likely also play a major role in the U.S. economy and its national security moving forward. And there are undoubtedly technologies which have yet to be created which, in the near-future, will have transformative effects on the lives and security of American citizens.

We are at the beginning of a new era, in which technologies not only are the principal driver of global markets and geopolitics, but they also advance and emerge faster than ever before. As the speed of technological development accelerates and an increasing number of technologies have dual-use applications, techno-national security threats will continue to multiply. To meet this challenge, the United States government must continually assess new technological advancements to determine their potential to disrupt industries, change economies, and transform national security.

The process of technology horizon-scanning, forecasting, and proactively crafting policies to address upcoming national security threats related to emerging technologies must become an ingrained component of the U.S. national security process. Doing so is not only essential, but also urgent. If the United States government waits to adapt to this new reality until a subsequent

International Renewable Energy Agency, (last accessed Feb. 2, 2021), <https://www.irena.org/Statistics/View-Data-by-Topic/Capacity-and-Generation/Country-Rankings>.

⁴³⁸ *Energy Storage*, U.S. Department of Energy (last accessed Feb. 2, 2021), <https://www.energy.gov/oe/energy-storage>.

⁴³⁹ *Energy Storage Grand Challenge: Roadmap*, U.S. Department of Energy (Dec. 2020), <https://www.energy.gov/sites/prod/files/2020/12/f81/Energy%20Storage%20Grand%20Challenge%20Roadmap.pdf>.

commission makes a similar recommendation, it will likely be playing technological catch-up from a position of national security weakness. As existing technologies evolve and new ones emerge, the relationship between technology and national security will only grow stronger, and the need for the United States to maintain overall technical leadership will only increase.

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END OF PART II

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