

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.¹ 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

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,² the list of “critical emerging technologies” produced by the Department of Defense in response to Section 1793 of the FY 2019 National Defense Authorization Act (NDAA),³ the Department of Commerce’s 2018 Advance Notice of Proposed Rulemaking (ANPRM) of controls on certain emerging technologies,⁴ 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 2020,⁵ and the bill introduced by Senator Chuck Schumer in the 116th Congress with seven bipartisan co-sponsors titled the “Endless Frontier Act.”⁶ 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.⁷ However, this document does not explain why each of these technologies is 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.**
 - o 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 associated implementation plans will form the core of a National Technology Strategy, as referenced in Chapter 9 of this report.
 - o 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.

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	✓	✓	✓		✓	✓
Autonomy and Robotics	✓	✓	✓		✓	✓
5G and Advanced Networking		✓		✓	✓	✓
Advanced Manufacturing			✓	✓	✓	✓
Energy Systems	✓	✓			✓	✓

- **Expand the loan authority of the Development Finance Corporation to include domestic industrial base capabilities supporting key emerging technologies.**
 - o The President should issue an Executive Order that 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 2022.⁸

- o 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 that 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 ensuring 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

Recommendation

The United States must invest in key platforms that 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 that 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 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.**
 - o 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 underfunded, difficult to access, and poorly curated, particularly in comparison to other leading genetic databases such as the U.K. 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.⁹
- **Direct funding to support advanced biotech manufacturing initiatives through entities such as BARDA.**
 - o 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

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 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.¹⁰ 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.**¹¹
 - o 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.¹² 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 that promote U.S. biotechnology leadership.**
 - o 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 that 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.¹³

Recommendation: Publicly Highlight BGI's Links to the Chinese Government

Recommendation

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.¹⁴ 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.¹⁵ 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.¹⁶ 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."¹⁷

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.**

- o 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.

Recommendation

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.¹⁸

Action for the Departments of State and Health and Human Services:

- **Support multilateral efforts to promote smart disease monitoring.**

- o 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 data sets 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 weapon systems.¹⁹ 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.²⁰ Failure to step up investment in the R&D 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.²¹

Recommendation: Transition from Basic Research to National Security Applications of Quantum Computing

Recommendation

Although the United States is well-positioned to take advantage of its early success in the basic science of quantum computing, the U.S. 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.²² 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.²³

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 that 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

Recommendation

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.²⁴ Although these materials and components may not yet represent choke points, they will inevitably become more specialized as the 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.²⁵ The U.S. Government should offer incentives for the R&D 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 toward extending U.S. leadership in next-generation computer hardware for years to come.²⁶

Action for Congress:

- **Enact a package of provisions that incentivizes the domestic design and manufacturing of quantum computers and their constituent materials.**
 - o 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 computers 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 14% of expenditures on R&D in excess of 50% of base period expenditures. To help startups on the cutting edge of research and development access funding that allows them to scale, the U.S. Government should also provide loan guarantees and equity financing.

Recommendation

Recommendation: Make Quantum Computing Accessible to Researchers via the National AI Research Resource (NAIRR)

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.²⁷ 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.²⁸ By making classical and quantum computers available in the same workflow, the U.S. Government would lower barriers to innovation for

startups 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 U.S. 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,²⁹ the U.S. 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 must preserve this access and trust while building out commercial 5G networks domestically and internationally.

Recommendation: Accelerate U.S. 5G Deployment Through Spectrum Sharing

Recommendation

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.³⁰ 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.³¹ 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.³²

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.³³ 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.³⁴ 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 that 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 more than \$4.5 billion through the sale of 20,625 licenses.³⁵ 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 operational effectiveness while also broadening commercial access to spectrum for civilian 5G networks.³⁶

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.**
 - o 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 21st century. The Commission assesses that 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.³⁷

Autonomy and Robotics

Recommendation: Incentivize the Development of World-Class Software Platforms for Robotic and Autonomous Systems

Recommendation

Autonomous systems that rely on robotics to execute tasks in the real world are being applied to everything from advanced manufacturing to warfighting.³⁸ 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 industry.³⁹ 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.**
 - o 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).⁴⁰ 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.⁴¹ 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

Recommendation: Accelerate Additive Manufacturing Production of Legacy Parts Across the Department of Defense

Recommendation

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.⁴² 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.⁴³ This link is particularly important in the defense sector, where communication between

researchers, designers, and manufacturers can help 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.⁴⁴ 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.⁴⁵ 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.⁴⁶

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.⁴⁷ 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.⁴⁸ The DoD 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 2025.⁴⁹

Energy Systems

Recommendation

Recommendation: Develop and Domestically Manufacture Energy Storage Technologies to Meet U.S. Market Demand by 2030

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.⁵⁰ As the cost of intermittent renewable sources 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 2030.⁵¹ 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.⁵²

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—everything from digital currencies and other types of financial technology to 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 that 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 U.S. 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 U.S. government waits to adapt to this new reality until a subsequent 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.

Blueprint for Action: Chapter 16 - Endnotes

¹ 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/>.

² *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>.

³ *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>.

⁴ 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>.

⁵ *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.

⁶ S. 3832, 116th Cong. (2020), <https://www.congress.gov/bill/116th-congress/senate-bill/3832>.

⁷ *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>.

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Blueprint for Action: Chapter 16 - Endnotes

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