Testimony before the Senate Select Committee on Intelligence

Countering the People's Republic of China's Economic and Technological Plan for Dominance

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Chairman Warner, Vice Chairman Rubio, members of the committee, thank you for the invitation.

China is keenly aware of its gaps and is using every means available to close them

In 2018, a Chinese state-run newspaper identified nearly three dozen crucial technologies that relied on specific imports that make China vulnerable to other countries' potential sanctions and export controls. In a series of articles, the full list of which is provided below in Appendix A, the authors covered topics including:

- The difficulty with producing rocket engines and aviation landing gear due to limitations in making high-strength steel;
- The challenges of building reliable high-resolution LiDAR (or light detecting and ranging sensors) that are the "eyes" of many unmanned vehicles; and
- Detailed gaps in China's ability to produce key semiconductor manufacturing equipment components.

These articles expressed the feeling that the United States and other powers could use these and other limitations to "strangle" China at any time.

The Chinese are keenly aware of their strengths *and* deficits, and are making strides toward achieving technological self-sufficiency. They regularly leverage a wide range of government powers in an attempt to dominate key technology areas — not just the cutting edge.

Understanding who is leading and following in emerging technologies between the United States and China requires evaluating comparative success across several key markers of leadership. These include research-driven knowledge creation, financial investment, human talent, intellectual property ownership, market share in technologies, and international standards and norm setting. Using these measures, it is helpful to understand what China sees as its comparative advantages or weaknesses in emerging technology development.

For example, an article published in January by the Institute for International and Strategic Studies at Peking University notes China's own technological strength has been improving progressively in recent years and it has become an influential science and technology (S&T) power. In artificial intelligence and machine learning, the Chinese consider themselves to be leading in product-driven research and development areas like facial and speech recognition, computer vision, and talent training at scale. In basic research, the United States and China are comparable in terms of scientific research paper publication and citation numbers. Yet the Chinese also know they lag behind the United States in original, groundbreaking research and in universities' and employers' ability to attract and retain top AI talent. Further, they view U.S. efforts to coordinate AI technology standards among global democracies as compounding their own problems with internally coordinating standards at different levels of government.

The United States still has a large lead over rapidly-advancing China in AI chips, algorithms, machine learning, and other core technologies; it leads in promoting military AI applications, and it has introduced ML technology in biosynthesis and drug R&D, achieving major breakthroughs. Though the United States relies heavily on foreign chip manufacturing, it maintains an overall technological advantage through its possession of intellectual property and the integration of IP in advanced semiconductor supply chains. Though China's circuit industry is rapidly developing, it faces redundancies and foreign dependencies that keep it well behind the United States. And the same Peking University study cited above also

notes that the technical strength gap between China and the United States in 5G and other communications technologies is narrow.

Beyond AI, the Chinese are also aware of the places where they maintain leverage over the United States in key parts of global supply chains. A December 2020 Congressional Research Service (CRS) report stated that, in 2019, 57.7 percent of U.S. imports of malaria diagnostic test kits came from China, as did more than 90 percent of key antibiotics and their derivative imports. As reported in a recent Nature article, the pandemic demonstrated the massive disruptive effects of China's dominance in bioeconomic supply chains for U.S. research and medical care, including backlogs of medical PPE and laboratory equipment vital to operations like gloves, pipette tips, and bleach for decontamination. Experimental materials including DNA extraction kits and research animals were also interrupted. Labs could not conduct any kind of research during this time, halting or slowing groundbreaking and innovative research.

China gaining advantages in any of these technologies, be it artificial intelligence, semiconductors, genome editing, or quantum technologies, would have implications for global security — and potentially, U.S. intelligence community operations.

The United States has three basic ways to shape its response

The United States needs to prepare now for the long term. As China's tech ecosystem matures and becomes increasingly innovative, the United States risks being surprised (and falling behind) because we don't have a comprehensive view of what China and other actors are doing across the technology landscape. I see three basic classes of responses for the United States and its allies that need to be used together to achieve the greatest effect: *run faster*, *slow competitors down*, and *monitor the entire science and technology landscape* more effectively.

First, the U.S. government could help the nation *run faster*. It could spur on the innovation ecosystem by expanding efforts to buy down risk, investing in innovation incubation, and reducing friction points that might slow U.S.-centric private sector innovation. An increase in funding focused on the transition of research and engineering innovations into American-made products would also yield positive domestic outcomes.

Second, the U.S. government can work with its allies to *slow down* the pursuing competition and *protect* critical technology. The United States should work with like-minded countries to maximize the effectiveness of export controls, sanctions and other related measures, as appropriate. However, these measures will not be effective on their own over time because they can be circumvented, require complicated multi-party coordination, create perverse incentives for tech firms to leave the United States, and spur China to innovate around them. Such methods are most useful when employed selectively in combination with *run faster* and the third option, S&T landscape monitoring.

Third, the United States must improve its monitoring of the science and technology landscape. Doing so is critical to our success in long-term competition with a high-tech peer. Specifically, Congress can support an analytic capability that monitors the S&T landscape and enables rapid adoption of new capabilities that offset Chinese advantages. It also is critical in fast follower situations. China's rapid rise in science and technology has been facilitated by more than 60,000 open-source collectors and analysts. China's large-scale S&T analysis capability has enjoyed massive, multi-layered and sustained state support. The resources devoted to these efforts allow China to prioritize technical areas for exploration and help ensure that the country is not surprised by worldwide innovations.

To my knowledge, no part of the U.S. government — including the intelligence community — has developed a scalable countermeasure to the Chinese approach. Instead, the United States relies on private sector parties to watch the threat and opportunity horizon, and has a limited S&T intelligence analysis capability that typically focuses on foreign threats in a handful of areas without comprehensive context. The United States has made no systematic, continuous, and scalable investment into the wholesale survey and monitoring of the worldwide S&T landscape. This analytic gap directly affects national security and economic competitiveness. And it undermines the country's ability to make informed technology-related decisions.

Analysis capabilities are essential to enable competition with a high-tech peer

CSET and others have proposed options to create this much-needed independent capability that uses unclassified sources to monitor global developments in emerging technologies. In fact, CSET has built a relevant prototype. To be effective, it must sit apart from the intelligence community due to authority and incentive challenges. The U.S. government needs a continuous analysis of the global S&T landscape to support strategic planning and decisions by federal, state, and local authorities in areas such as the following:

- Prioritization of R&D investment and divestment;
- Expert finding, selecting collaborations, and partnerships; and
- Timely insight on the constantly changing targets of unwanted tech transfer.

A well-resourced S&T analysis and monitoring organization with sustained funding:

- Creates an unclassified foundation on top of which more sensitive threat work can be overlaid;
- Functions seamlessly across foreign and domestic technological challenges;
- Assembles a critical mass of resources that are hard to find due to high setup costs, such as technical infrastructure, data resources, expert technical input, and analytic talent; and
- Works to enable innovations to move from research to practice.

We need to embrace this transformative S&T landscape monitoring mission. When used in combination with "run faster" and "slow them down" policy options, it will help maintain U.S. leadership in critical emerging technologies and supply chains — now and into the future.

Thank you, and I look forward to our discussion.

Appendix A: Citation Information for the 35 "Chokepoints" Articles

Article	Citation
(1) Photolithography machines	本报记者高博 [staff reporter Gao Bo], "这些'细节'让中国难望顶级光刻机项背" ["These 'Details' Keep Top Photolithography Machines a Distant Prospect for China"], 科技日报 [*S&T Daily*], April 19, 2018, 1, 3, https://perma.cc/5DGC-8786 and https://perma.cc/BZK5-F8QE.[1]
(2) Microchips	本报记者张盖伦、付丽丽 [staff reporters Zhang Gailun and Fu Lili], "中兴的'芯'病，中国的心病" ["ZTE's Chip Problem Gives China Heart Palpitations"], 科技日报 [*S&T Daily*], April 20, 2018, 1, 3, https://perma.cc/H8XT-6Z6Q and https://perma.cc/E89F-Y9JT.
(3) Operating systems	本报记者高博 [staff reporter Gao Bo], "丧失先机，没有自研操作系统的大国之痛" ["Lost Opportunities: The Pains of a Great Power Without a Domestically Developed Operating System"], 科技日报 [*S&T Daily*], April 23, 2018, 1, https://perma.cc/DL52-V2VL.
(4) Aircraft engine nacelles	本报记者矫阳 [staff reporter Jiao Yang], "居者无其屋，国产航空发动机的短舱之困" ["No Homes of Their Own: The Nacelle Problem of Domestic Aircraft Engines"], 科技日报 [*S&T Daily*], April 24, 2018, 1, https://perma.cc/3GP8-UMDQ.
(5) Touch sensors (for industrial robots)	本报记者张佳星 [staff reporter Zhang Jiaxing], "传感器疏察，被愚钝的机器人'国产触觉'" ["An Oversight in Sensors, a 'Domestic Touch' for Dumbed-Down Robots"], 科技日报 [*S&T Daily*], April 25, 2018, 1, 4, https://perma.cc/A3JG-V8F2 and https://perma.cc/6SQ5-25TP.
(6) Vacuum evaporators	本报记者刘艳 [staff reporter Liu Yan], "真空蒸镀机匮缺：高端显示屏上的阴影" ["Vacuum Evaporator Shortage: A Shadow over High-End Displays"], 科技日报 [*S&T Daily*], April 26, 2018, 1, 3, https://perma.cc/4KMP-NE8P and https://perma.cc/ZU9A-9LAC.
(7) High-end radio frequency (RF) components	本报记者高博 [staff reporter Gao Bo], "射频器件：仰给于人的手机尴尬" ["RF Components: For Mobile Phones, an Embarrassing Reliance on Others"], 科技日报 [*S&T Daily*], May 7, 2018, 1, 4, https://perma.cc/6CJH-HRYM and https://perma.cc/5UQ2-J6CB.
(8) Primers and reagents used for iCLIP technology (for RNA manipulation)	本报记者张佳星 [staff reporter Zhang Jiaxing], "'靶点'难寻，国产创新药很迷惘" ["'Targets' Are Elusive, Leaving Domestic Production of Innovative Drugs in a Fog"], 科技日报 [*S&T Daily*], May 8, 2018, 1, 3, https://perma.cc/6JF4-4VJ5 and https://perma.cc/C9UE-M4TG.
(9) Heavy-duty gas turbines	本报记者瞿剑 [staff reporter Qu Jian], "'命门火衰'，重型燃气轮机的叶片之殇" ["'Weakness between the Kidneys'—The Blade Wounds of Heavy-Duty Gas Turbines"], 科技日报 [*S&T Daily*], May 9, 2018, 1, 4, https://perma.cc/H9SV-LDWU and https://perma.cc/WW9D-RSM8.

[1] Most of the "chokepoints" articles published by Chinese state-run newspaper *Science and Technology Daily* (*S&T Daily*; 科技日报) in 2018—profiled in the upcoming CSET report "Chokepoints: China's Self-Identified Strategic Technology Import Dependencies"—begin on page one and continue onto a subsequent page. In these cases, we provide two URLs. The first one links to a PDF of page one of the relevant issue of *S&T Daily*, a page that includes the first half of the "chokepoints" article among other articles. The second PDF is of the page of the newspaper that contains the second half of the "chokepoints" article in question.

(10) LiDAR	实习记者崔爽 [reporter intern Cui Shuang], "激光雷达昏聩，让自动驾驶很纠结" ["LiDAR Dimness Leaves Autonomous Driving in a Tangle"], 科技日报 [*S&T Daily*], May 10, 2018, 1, 3, https://perma.cc/SCA7-XVBN and https://perma.cc/KRK3-P5LA.
(11) Airworthiness standards	本报记者矫阳 [staff reporter Jiao Yang], "适航标准：国产航发又一道难迈的坎儿" ["Airworthiness Standards: Another Difficult Hurdle for Domestic Aircraft Engines"], 科技日报 [*S&T Daily*], May 11, 2018, 1, 3, https://perma.cc/669C-55H8 and https://perma.cc/FZ7U-AR3W.
(12) High-end capacitors and resistors	本报记者高博 [staff reporter Gao Bo], "没有这些诀窍，我们够不着高端电容电阻" ["Without This Know-How, High-End Capacitors and Resistors Will Remain Beyond Our Reach"], 科技日报 [*S&T Daily*], May 14, 2018, 1, 4, https://perma.cc/57QK-KFUJ and https://perma.cc/FBN7-2ADB.
(13) Electronic design automation (EDA) software	本报记者俞慧友 [staff reporter Yu Huiyou], "核心工业软件：智能制造的中国'无人区'" ["Core Industrial Software: China's 'Uncharted Territory' in Smart Manufacturing"], 科技日报 [*S&T Daily*], 1–2, May 17, 2018, https://perma.cc/7GW3-J2T5 and https://perma.cc/4U7J-RHV9.
(14) High-end indium tin oxide (ITO) sputtering target materials	本报记者赵汉斌 [staff reporter Zhao Hanbin], "烧不出大号靶材，平板显示制造仰人鼻息" ["Unable to Sinter Large-Size Targets, Panel Display Manufacturing Depends on Others for Survival"], 科技日报 [*S&T Daily*], May 18, 2018, 1, 4, https://perma.cc/DXH8-XXGN and https://perma.cc/J9LC-RTL4.
(15) Core algorithms (for robotics)	本报记者杨仑 [staff reporter Yang Lun], "算法不精，国产工业机器人有点'笨'" ["With Inept Algorithms, Domestically Produced Robots Are a Bit 'Slow'"], 科技日报 [*S&T Daily*], May 22, 2018, 1, 3, https://perma.cc/QP2T-RBCN and https://perma.cc/EY6D-UWJP.
(16) Aviation-grade steel (for landing gear)	本报记者孙玉松 [staff reporter Sun Yusong], "航空钢材不过硬，国产大飞机起落失据" ["Weak in Aviation-Grade Steel, Large Domestic Aircraft Lack Support for Takeoff and Landing"], 科技日报 [*S&T Daily*], May 23, 2018, 1–2, https://perma.cc/PT8S-6AKK and https://perma.cc/73ST-RYWR.
(17) Milling cutters	本报记者华凌 [staff reporter Hua Ling], "为高铁钢轨'整容'，国产铣刀难堪重任" ["For High-Speed Railway Track 'Facelifts,' Domestic Milling Cutters Are Not Up to the Task"], 科技日报 [S&T Daily], May 24, 2018, 1, https://perma.cc/W4VP-4YAR.
(18) High-end bearing steel	本报记者王延斌 [staff reporter Wang Yanbin], "高端轴承钢，难以补齐的中国制造业短板" ["High-End Bearing Steel, a Difficult Shortcoming for Chinese Manufacturing to Overcome"], 科技日报 [*S&T Daily*], May 25, 2018, 1, https://perma.cc/26AR-FFKY.
(19) High-pressure piston pumps (for hydraulic machinery)	本报记者王海滨、通讯员王玉芳 [staff reporter Wang Haibin and correspondent Wang Yufang], "高压柱塞泵，鲠在中国装备制造业咽喉的一根刺" ["High-Pressure Piston Pumps: A Thorn in the Side of China's Equipment Manufacturing Industry"], 科技日报 [*S&T Daily*], May 28, 2018, 1, 3, https://perma.cc/XA2S-QBGQ and https://perma.cc/WV9R-NN3Q.
(20) Aviation design software	本报记者张晔 [staff reporter Zhang Ye], "航空软件困窘，国产飞机设计戴上'紧箍咒'" ["Aviation Software Plight Has Domestic Aircraft Design under a 'Skull-Squeezing Curse'"], 科技日报 [*S&T Daily*], May 30, 2018, 1, 3, https://perma.cc/RU6C-MTQS and https://perma.cc/U9HU-YC5V.
(21) High-end photoresists (for photolithography)	本报记者过国忠 [staff reporter Guo Guozhong], "中国半导体产业因光刻胶失色" ["China's Semiconductor Industry Losing Its Luster Due to Photoresists"], 科技日报 [*S&T Daily*], May 31, 2018, 1, 3, https://perma.cc/MYL5-PYGZ and https://perma.cc/KD25-QMZW.

(22) High-pressure common rail direct fuel injection systems (for low-emission diesel engines)	本报记者江东洲、刘昊 [staff reporters Jiang Dongzhou and Liu Hao], “高压共轨不中用，国产柴油机很受伤” [“When High-Pressure Common Rail Is No Good, Domestic Diesel Engine Production Suffers”], 科技日报 [*S&T Daily*], June 4, 2018, 1, 4, https://perma.cc/T7JN-4GU7 and https://perma.cc/R83U-KFA4.
(23) Transmission electron microscopes (TEM)	本报记者张佳星 [staff reporter Zhang Jiaxing], “我们的蛋白质3D高清照片仰赖舶来的透射式电镜” [“High-Definition 3D Photographs of Our Proteins are Dependent on Foreign Transmission Electron Microscopes”], 科技日报 [*S&T Daily*], June 6, 2018, 1, 4, https://perma.cc/HX2Z-BF6V and https://perma.cc/6YPW-346K.
(24) Main bearings for tunnel boring machines (TBM)	本报记者矫阳 [staff reporter Jiao Yang], “自家的掘进机却不得不用别人的主轴承” [“Chinese-Made Tunnel Boring Machines Have to Use Main Bearings from Others”], 科技日报 [*S&T Daily*], June 7, 2018, 1, 3, https://perma.cc/SD3Z-E622 and https://perma.cc/QJA5-WMUM.
(25) Microspheres	本报记者高博 [staff reporter Gao Bo], “微球：民族工业不能承受之轻” [“Microspheres: The Unbearable Lightness of National Industry”], 科技日报 [*S&T Daily*], June 12, 2018, 1, 3, https://perma.cc/TF8V-L8ZX and https://perma.cc/P27W-8LSP.
(26) Underwater connectors	本报记者陈瑜 [staff reporter Chen Yu], “水下连接缺国产利器，海底观测网傍人篱壁” [“With No Domestic Producers of Underwater Connectors, Seafloor Observation Network Depends on Others”], 科技日报 [*S&T Daily*], June 13, 2018, 1, 4, https://perma.cc/K8ZS-6JWZ and https://perma.cc/G93B-6SH6.
(27) Key materials for fuel cells	本报记者张盖伦 [staff reporter Zhang Gailun], “少了三种关键材料，燃料电池商业化难成文章” [“Without Three Key Materials, Fuel Cell Commercialization Will Be Hard to Achieve”], 科技日报 [*S&T Daily*], June 14, 2018, 1, 3, https://perma.cc/EQ5E-GYGV and https://perma.cc/6NAR-HB27.
(28) High-end welding power sources (for underwater welding robots)	本报记者叶青、龙跃梅 [staff reporters Ye Qing and Long Yuemei], “国产焊接电源‘哑火’，机器人水下作业有心无力” [“Domestic Production of Welding Power Sources ‘Misfires,’ Frustrating Underwater Robot Operations”], 科技日报 [*S&T Daily*], June 20, 2018, 1, 4, https://perma.cc/UZG7-NBU7 and https://perma.cc/47XR-D898.
(29) Lithium battery separators	本报记者孙玉松 [staff reporter Sun Yusong], “一层隔膜两重天：国产锂电池尚需拨云见日” [“One Layer of Separators, Two Very Different Environments: Domestic Lithium Battery Production Still Waiting for the Clouds to Part”], 科技日报 [*S&T Daily*], June 21, 2018, 1, 3, https://perma.cc/DN9Q-C6T6 and https://perma.cc/42QZ-EYNV.
(30) Components for medical imaging equipment	本报记者张佳星 [staff reporter Zhang Jiaxing], “拙钝的探测器模糊了医学影像” [“Dull Detectors Blur Medical Imaging”], 科技日报 [*S&T Daily*], June 25, 2018, 1, 4, https://perma.cc/H62R-UUH7 and https://perma.cc/6SZ3-XU3T.
(31) Ultra-precision polishing techniques	本报记者张景阳 [staff reporter Zhang Jingyang], “通往超精密抛光工艺之巅，路阻且长” [“In Ultra-Precision Polishing Techniques, the Road to the Top is Long and Rocky”], 科技日报 [*S&T Daily*], June 26, 2018, 1, 3, https://perma.cc/N6V6-FETT and https://perma.cc/LLZ2-2G7H.
(32) Epoxy (for high-end carbon fiber)	本报记者李禾 [staff reporter Li He], “环氧树脂韧性不足，国产碳纤维缺股劲儿” [“Insufficient Resiliency in Epoxy Means Domestic Carbon Fiber Lacks Strength”], 科技日报 [*S&T Daily*], June 27, 2018, 1, 4, https://perma.cc/2TVR-8PZK and https://perma.cc/SU6R-E4Y5.

(33) High-strength stainless steel (for rocket engines)	本报记者付毅飞、实习记者于紫月 [staff reporter Fu Yifei and reporter intern Yu Ziyue], "去不掉的火箭发动机'锈疾'" ["The Intractable 'Rust Disease' of Rocket Engines"], 科技日报 [*S&T Daily*], June 28, 2018, 1, 3, https://perma.cc/KH74-9FKL and https://perma.cc/TTV7-CY7R.
(34) Database management systems	本报记者高博 [staff reporter Gao Bo], "数据库管理系统：中国还在寻找'正确打开方式'" ["Database Management Systems: China still Looking for the 'Right Way to Open'"], 科技日报 [*S&T Daily*], July 2, 2018, 1, 4, https://perma.cc/MDR9-JJCG and https://perma.cc/3ZEP-2DZX.
(35) Scanning electron microscopes (SEM)	实习记者陆成宽 [reporter intern Lu Chengkuan], "扫描电镜'弱视'，工业制造难以明察秋毫" ["Scanning Electron Microscope 'Visual Impairment' Makes Minute Observation Difficult for Industrial Manufacturing"], 科技日报 [*S&T Daily*], July 3, 2018, 1, 3, https://perma.cc/VWV2-AFDP and https://perma.cc/9LVG-V9ES.

Appendix B: Recommended Reading

Zachary Arnold and Melissa Flagg, "A New Institutional Approach to Research Security in the United States" (Center for Security and Emerging Technology, January 2021). https://cset.georgetown.edu/publication/a-new-institutional-approach-to-research-security-in-the-united-states/

Tarun Chhabra, William Hannas, Dewey Murdick, and Anna Puglisi, "Open-Source Intelligence for S&T Analysis" (Center for Security and Emerging Technology, September 2020). https://cset.georgetown.edu/publication/open-source-intelligence-for-st-analysis/

CSIS Technology and Intelligence Task Force, "Maintaining the Intelligence Edge: Reimagining and Reinventing Intelligence through Innovation" (Center for Strategic and International Studies, January 2021). https://www.csis.org/analysis/maintaining-intelligence-edge-reimagining-and-reinventing-intelligence-through-innovation

Ryan Fedasiuk, Emily Weinstein, and Anna Puglisi, "China's Foreign Technology Wish List" (Center for Security and Emerging Technology, May 2021). https://cset.georgetown.edu/publication/chinas-foreign-technology-wish-list/

Melissa Flagg and 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, September 2020). https://cset.georgetown.edu/publication/system-re-engineering/

William Hannas and Huey-Meei Chang, "China's STI Operations" (Center for Security and Emerging Technology, January 2021). https://cset.georgetown.edu/publication/chinas-sti-operations/

Will Hunt, "Sustaining U.S. Competitiveness in Semiconductor Manufacturing" (Center for Security and Emerging Technology, January 2022). https://cset.georgetown.edu/publication/sustaining-u-s-competitiveness-in-semiconductor-manufacturing/

Ben Murphy, "Chokepoints: China's Self-Identified Strategic Technology Import Dependencies" (Center for Security and Emerging Technology, May 2022). Forthcoming

Alex Rubin, Alan Omar Loera Martinez, Jake Dow, and Anna Puglisi "The Huawei Moment" (Center for Security and Emerging Technology, July 2021). https://cset.georgetown.edu/publication/the-huawei-moment/

Wang Jisi, Zhao Jianwei, Hu Ran, Zhang Chengyang, and Zhang Yike, "Sino-U.S. Strategic Competition in the Technology Domain: Analysis and Outlook" (Institute for International and Strategic Studies at Peking University, January 2022). http://cn3.uscnpm.org/model_item.html?action=view&table=article&id=27016