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Before the Senate Subcommittee on Science,
Manufacturing and Competitiveness

"Measuring What Matters: Science, Standards, and Strategic Competition"

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Chairman Budd, Ranking Member Baldwin, members of the Committee and distinguished participants. It's a privilege to testify on the state of U.S. science, technology, engineering, and manufacturing for our Nation's global economic competitiveness and national security, particularly in relation to China's ascendance.

The state of the great power competition between the U.S. and China is a focus of the work with the Center for Strategic and International Studies (CSIS), where I serve as Senior Advisor for the Renewing American Innovation project. It has been my honor over the past 5 years to lead research and technology transfer at Colorado School of Mines, a top tier U.S. research university rated in the top 3 engineering programs in America. I previously served our Nation as Director of the National Institute of Standards and Technology, for which this Committee has oversight, and prior, with two of the U.S. Department of Energy national labs. My leadership experience spans public and private sectors—as executive, entrepreneur and investor.

Two decades ago, the United States was the undisputed global leader in science and technology, and in driving innovation for economic value. America's research universities and institutions attracted and welcomed the brightest and best talent from around the world to contribute to our science and engineering enterprise, with many ultimately to become citizens and participants in our National prosperity. Today, however, by many internationally recognized measures, America's global leadership

position in the majority of critical technology fields has been overtaken by China.[1] By 2024, China surpassed the U.S. in total R&D investment, and, rather than just being considered a perpetrator of IP theft, China has become a globally recognized force through its own strengths and modern built infrastructure for science, engineering and innovation.[2] China is currently seen as leading in 57 of 64 technology categories essential to the global economy, while the U.S. still holds the clear lead in the remaining seven.[3,4]

China now leads in numbers of patents[5] and highly cited top tier research publications in respected journals,[6] having also strengthened their IP system[7] while further seeking to dominate global technology standards.[8] At the same time, the U.S. has allowed the strength of our intellectual property protections to decline[9,10] contributing to a net devaluation of U.S. intellectual properties in global markets.[11] China now dramatically outpaces the U.S and other nations in international priority patent families granted in critical technologies including biotechnology, quantum information science and engineering, robotics, semiconductors and artificial intelligence. China's national focus on standards leadership and IP has further resulted in a substantially increased rate of accepted

[1] The State of U.S. Science and Engineering, 2026: https://ncses.nsf.gov/pubs/nsbsep20261

[2] The Power of Innovation: The Strategic Value of China's High-Tech Drive: https://www.csis.org/analysis/power-innovation-strategic-value-chinas-high-tech-drive

[3] ASPI's Two-Decade Critical Technology Tracker, https://www.aspi.org.au/report/aspis-two-decade-critical-technology-tracker

[4] State of the Science Address: 2026, https://www.nationalacademies.org/events/113research productivity in critical technology areas a3 https://www.nationalacademies.org/news/2024/06/in-state-of-the-science-address-nas-president-urges-improvements-to-k-12-science-education-in-order-to-strengthen-the-u-s-stem-workforce

[5] https://itif.org/publications/2023/01/23/wake-up-america-china-is-overtaking-the-united-states-in-innovation-capacity/

[6] https://www.nationalacademies.org/news/2024/06/in-state-of-the-science-address-nas-president-urges-improvements-to-k-12-science-education-in-order-to-strengthen-the-u-s-stem-workforce

[7] Translating IP Into Revenue: China's Changing Place in the Global IP Landscape: https://www.csis.org/blogs/trustee-china-hand/translating-ip-revenue-chinas-changing-place-global-ip-landscape

[8] What Washington Gets Wrong About China and Technical Standards: https://carnegieendowment.org/research/2023/02/what-washington-gets-wrong-about-china-and-technical-standards?lang=en

[9] Intellectual Property Rights in the U.S.-China Innovation Competition: https://www.csis.org/analysis/intellectual-property-rights-us-china-innovation-competition

[10] Losing the Lead: Why the United States Must Reassert Itself as a Global Champion for Robust IP Rights https://itif.org/publications/2023/06/12/losing-the-lead-why-united-states-must-reassert-itself-as-global-champion-for-robust-ip-rights/

[11] Intellectual Property Litigation: U.S. Trends in Global Perspective: https://www.cornerstone.com/wp-content/uploads/2026/06/IP-Litigation-US-Trends-in-Global-Perspective-June-2026.pdf

contributions to international standards by Chinese entities over the past 10 years.[12]

Measuring the context of strategic advantage in the technology domains that matter to the future of the economy and national security, however, also requires taking an ecosystem view that considers the fundamentals and strategic enablers of competitiveness.[13] The CSIS Economic Security and Technology Tech Edge methodology[14] takes into account these ecosystem factors across four distinct technology types based on breadth of application and production complexity. These include:

1. Stack technologies (e.g., biotech, AI and advanced chips, requiring deep capital markets, collaborative research networks, and platform orchestration)
2. Precision technologies (e.g., jet engines and lithography, which demand trusted partnerships and gold-standard certification regimes)
3. Production technologies, (e.g., high-end machine tools, robotics and industrial process automation, which need long-term capital and ongoing workforce training)
4. Base technologies (e.g., rare earth elements, batteries, steel and aluminum alloys, which require coordinated supply chains and processing infrastructure)

This analysis indicates U.S. leadership advantage in Stack and Precision technologies, whereas China is increasingly competitive in Production technologies and dominant in Base technologies. In the face of the competition with China, achieving the technological dexterity to build ecosystem strengths across multiple technology types is a strategic imperative for the Nation.

[12] China's High-Tech Drive in 10 Charts: https://www.csis.org/analysis/chinas-high-tech-drive-10-charts
[13] Tech Edge, A Living Playbook for America's Technology Long Game - https://www.csis.org/analysis/tech-edge-living-playbook-americas-technology-long-game
[14] https://csis-website-prod.s3.amazonaws.com/s3fs-public/2026-01/260120_EST_Tech_Edge_0.pdf?VersionId=MJKGLWqbgviv53jbBuWHg32poCRpHJAL

We are now at an inflection point where China's ascendance toward innovation peer status presents America with both risk and opportunity.[15] The U.S. must take a new strategic approach to the future of research and S&E advancement that coordinates across government agencies. We must leverage collaboration and investments with the private sector,[16] bolster education at all levels, and effectively engage our national R&D, intellectual property, standards and innovation enterprise.[17] We have the chance to drive great synergies in our federal R&D investment through a national S&T and innovation strategy that takes the long view.

At the end of World War II, Vannevar Bush and his seminal report "Science: The Endless Frontier" ushered in a new era of research and innovation for the U.S. America's sustained investment in public-sector R&D has proven to be an essential contributor to our global competitiveness,[18] though its strategic value and high rates of investment return[19] are not always fully appreciated.[20] It is well documented that substantial industrial productivity gains[21] and the majority of our tech startups now originate from public R&D funding.[22,23]

Commencing in 2025, the U.S. R&D enterprise has experienced seismic shifts which have disrupted the pace and continuity of research programs, negatively affecting research productivity, graduate education, international partnerships, innovation outcomes, and more. Current indicators are clear: the pace of progress in priority technologies for the nation, including quantum, biotech and emerging energy has decelerated,

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[15] Will America Squander Its New Sputnik Moment? https://www.csis.org/analysis/will-america-squander-its-new-sputnik-moment

[16] The State of U.S. Science and Engineering, 2026: https://ncses.nsf.gov/pubs/nsbsep20261

[17] U.S. Research and Innovation Performance, Elsevier, 2026: https://www.elsevier.com/promotions/us-research-and-innovation-performance

[18] Competing in the Next Economy. Innovating in the Age of Disruption and Discontinuity. A Call to Action: https://compete.org/wp-content/uploads/coc-disruption_discontinuity-call-to-action-final_12.13.24.pdf

[19] Federal R&D Funding Is Even More Valuable Than Washington Thinks: https://www.aei.org/economics/federal-rd-funding-is-even-more-valuable-than-washington-thinks/

[20] Fieldhouse, A.J., & Mertens, K. (2023). The Returns to Government R&D: Evidence from U.S. Appropriations Shocks. Working paper. https://andrewjfieldhouse.com/wp-content/uploads/2023/12/The_Return_to_Government_R_D_manuscript.pdf

[21] NBER "Estimating the Economic and Budgetary Effects of Research Investments" https://www.nber.org/papers/w33402)

[22] Dyèver, A. (2024) Public R&D Spillovers and Productivity Growth: https://www.ecb.europa.eu/press/conferences/ecbforum/shared/pdf/2024/EFCB_2024_Dyevre_paper.en.pdf

[23] Fleming, L., Greene, H., Li, G., Marx, M., & Yao, D. A. (2019). Government-funded research increasingly fuels innovation. *Science*, *364* (6446), 1139–1141. https://doi.org/10.1126/science.aaw2373

affected by grant cancellations, funding slowdowns, staff losses, programmatic discontinuity and uncertainties. America's research and engineering workforce is experiencing its largest loss of talent in history, and other nations are taking advantage.[24] The OMB's proposed rule to revise the Guidance for Federal Financial Assistance (Docket OMB-2026-0034) has resulted in significant feedback on the future fundamentals of how federally funded R&D will be conducted.[25] Clearly, the U.S. R&D enterprise must move more quickly, align with national priorities, and be good stewards of tax dollars. However, the guidance as drafted would most certainly have the opposite effects, with a cascade of unintended consequences. The nation must learn from its unforced errors, and to avoid delays and disruptions to U.S. research that are particularly costly in view of the accelerating pace of the global innovation race.

To translate invention to impact, preserving the integrity of the Bayh-Dole Act for U.S. innovation is essential.[26,27] We must now implement a much-needed modernization of the Stevenson-Wydler Act to deliver increased innovation outcomes from federal research, and NIST Green Paper on "Unleashing American Innovation" and the "Return on Investment" Legislative Proposal delivered to Congress in 2020 provide a starting point to achieve these goals.[28] Enabling more flexible and efficient collaborations between universities, government, industry and science philanthropy are key to America's success in S&T across the nation's innovation ecosystems.[29]

The United States is at a crucial juncture for the future of American innovation leadership globally. Our economic security and national security are closely intertwined with the reliability and the protections afforded by our R&D, IP, standards and innovation ecosystem. The foundational strength of U.S. IP rights, as established by the framers of

[24] America's Scientific Brain Drain Is No Longer Hypothetical: https://www.realclearscience.com/articles/2026/07/14/americas_scientific_brain_drain_is_no_longer_hypothetical_1194182.html

[25] https://www.science.org/content/article/u-s-researchers-outraged-proposed-changes-federal-grants

[26] Copan, W.G., America's Goose that Lays the Golden Eggs: https://rollcall.com/2021/04/22/americas-goose-that-lays-the-golden-eggs/

[27] Unleashing American Innovation, NIST Green Paper SP1234, https://www.nist.gov/unleashing-american-innovation/green-paper

[28] ROI Initiative Status Update: Legislative Package Sent to Congress: https://www.nist.gov/news-events/news/2020/12/roi-initiative-status-update-legislative-package-sent-congress

[29] McNutt, M. (2024) Keeping America "Science Strong," https://pmc.ncbi.nlm.nih.gov/articles/PMC11459151/

the Constitution, must be enhanced with the enforceability of the rights of inventors in the U.S. and abroad, together with the rule of law and global respect for private contracts. These are particularly important for standard essential patents (SEPs), where the U.S. still leads the world as a net exporter of innovation. Reliable IP rights licensed to development and manufacturing partners enable trusted global supply chains and value creation for consumers and shareholders alike. The mobile telecommunications sector contributes an estimated total economic value of more than $4.8 trillion to the global economy.[30] Technology innovators, including holders of SEPs, gain returns on their investments in R&D and standards engagement through licenses and royalty payments, in addition to product and services sales. Global intellectual property commerce, driven by SEP licensing, was $1.1 Trillion in 2023, with a net positive balance of trade in intellectual assets to the U.S. of over $130 Billion.[31]

However, there is widespread unlicensed technology use in China of innovations and IP assets owned by U.S. entities. Further, China's government has weaponized its legal system with a wide range of patent and competition law tools, price controls on international entities, forced technology transfers, and by providing selective legal protections and incentives seeking to advantage Chinese companies.[32]

There is a concerning movement away from market-based negotiations and valuation toward government-controlled price regulation for standardized technologies. The EU has proposed a massive new regulatory regime[33] toward government control of SEP prices. The Chinese Communist Party has issued guidelines that would also apply its antitrust laws to SEP licenses to benefit Chinese entities.[34]

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[30] https://s3.amazonaws.com/media.hudson.org/The+Western+Innovators+of+the+Mobile+Revolution_+The+Data+on+Global+Royalty+Flows+to+U.S.+and+Europe+and+Why+It+Matters+-+Jan+2024.pdf

[31] Global Innovation Index: https://www.wipo.int/en/web/global-innovation-index/w/blogs/2025/international-trade

[32] DOI: https://doi.org/10.15779/Z38XP6V46N

[33] https://single-market-economy.ec.europa.eu/publications/com2023232-proposal-regulation-standard-essential-patents_en

[34] https://www.allenovery.com/en-gb/global/news-and-insights/publications/china-draft-sep-antitrust-guideline-released-by-samr-for-public-comment

Supported by Chinese government incentives, legal actions and long-term strategy, China's technology companies are gaining ground.[35] In the development of 5G wireless broadband standards in the 3GPP (Third Generation Partnership Project) multi-stakeholder consortium, four Chinese companies were in the top 10 list of providing approved contributions to the standard: China Academy of Telecommunications Technology (CATT), China Mobile, ZTE, and substantially led by Huawei;[36] two U.S.-headquartered companies were on this list: Qualcomm and Intel. In 2019, the U.S. placed restrictions on having engagements with those Chinese organizations on the Commerce "entity list." This became a self-inflicted wound for the open technology standards process, damaging the positions of American companies and global partners.[37] We must learn from this experience, among many other lessons, about the strategic importance of maintaining open and fair international engagement for standards, metrology and trade.[38]

Engagement in global collaborations for critical emerging technologies is an essential part of standards development and testing for the U.S. to ensure that common principles are established, and ultimately to support rather than impede the pace of technology innovation. International partnership networks enable the U.S. to establish an effective perspective and the balance between voluntary consensus standards and regulations for innovative new technologies, including artificial intelligence, emerging biotechnologies and quantum systems.

It is essential for the U.S. to provide leadership globally, taking deliberate steps to expand standards engagement and enforce the rights of American innovators here and abroad. We must systemically encourage and incentivize engagement in standards development – for companies large and small, for academia and for government entities. Developing standards literacy as part of U.S. higher education in STEM as well as in economics, business and legal curricula must also be a key priority. As

[35] https://www.telegraph.co.uk/business/2024/04/30/huawei-profits-surge-steal-market-share-apple-china/
[36] China's High-Tech Drive in 10 Charts: https://www.csis.org/analysis/chinas-high-tech-drive-10-charts
[37] U.S. drafts rule to allow Huawei and U.S. firms to work together on 5G standards: https://www.reuters.com/article/technology/exclusive-us-drafts-rule-to-allow-huawei-and-us-firms-to-work-together-on-5-idUSKBN22K214/
[38] United States Standards Strategy (USSS) 2025: https://www.nist.gov/standardsgov/united-states-standards-strategy-released

we look to rebuild America's advanced manufacturing base and a trained domestic workforce, as well as trusted, resilient supply chains, the U.S must build upon the strengths of our free market economy, and a reliable intellectual property and innovation system that once again must lead the world.

The future U.S. workforce must have the skills necessary for the STEM-related careers that drive the innovation economy. A prepared workforce is essential for rebuilding and reshoring our advanced manufacturing base for all industries in the economy of the future. The Manufacturing USA Institutes have essential roles to play for the future of America's manufacturing technology base and workforce development. A recent report by the U.S. National Academies provides a wealth of analysis and powerful insights for the future of this manufacturing innovation and support infrastructure to help counter the decline in American manufacturing productivity growth over the past two decades.[39]

America's small- and medium-sized manufacturers are essential parts of the nation's supply chains and innovation system. Rechartering and fully supporting the Manufacturing Extension Partnership (MEP) in an expanded mission for the U.S. to drive manufacturing innovation, entrepreneurship, shared services and advanced manufacturing technology efficiencies must be considered well by this Committee and stakeholders.

We have much work to do. America's K-12 educational outcomes[40] have fallen behind other nations. Preparing future leaders with modernized higher education pathways and a pragmatic base of experience with flexibility for a range of interdisciplinary career journeys will be essential.[41] Attracting and retaining talented people from other nations also remains vital to our innovation economy.[42] Further, international

[39] A Vision for the Manufacturing USA Program in 2030 and 2035: https://www.nationalacademies.org/projects/DEPS-NMMB-24-01/publication/29295

[40] U.S. Department of Education Issues Statement on the Nation's Report Card: https://www.ed.gov/about/news/press-release/us-department-of-education-issues-statement-nations-report-card

[41] Leadership development in U.S. Higher education: Strategies for lifelong learning and upskilling: https://www.econstor.eu/bitstream/10419/327649/1/S2444569X2500099X.pdf

[42] Foreign-born Share of the U.S. STEM Workforce, https://www.csis.org/analysis/innovation-lightbulb-foreign-born-share-us-stem-workforce

scientific collaborations – with like-minded nations who are technology leaders as well as with developing countries in the Global South – enable the acceleration of discoveries, building diplomacy, talent access and supply chain resilience that also supports America's position abroad.[43]

Over the past two decades, the bureaucracy and administrative burdens associated with American publicly funded R&D have also skyrocketed.[44] This bureaucracy has increased the costs and reduced the productivity of U.S. research. We must continually increase efficiencies in S&T across technology domains, drive speed-to-scale for innovation, build interagency coordination, and strengthen intellectual property, technology standards leadership and our international partnerships. The National Science and Technology Council must be fully revitalized for truly effective interagency coordination toward maximizing efficiencies and the value created from public R&E investment. We must further modernize legislation and policies to remove barriers and incentivize innovation for America to continue to lead the world. The U.S. must defend its innovators at home and abroad against mercantile and malign threats.

Thanks to this Committee for your important work toward securing the science, technology and innovation leadership for U.S. economic and national security. I look forward to answering questions you may have.

[43] Preserving America's Place in Global Science, T. Smith (2024): https://nautil.us/preserving-americas-place-in-global-science-1031512/

[44] Changes in Federal Research Requirements Since 1991: https://www.cogr.edu/changes-federal-research-requirements-1991