AUVSI Partnership for Robotics Competitiveness

Securing U.S. Leadership in Robotics and Physical Artificial Intelligence

Executive Summary

For decades, the United States has led the world in advanced technology and manufacturing, pioneering breakthrough innovations which have underpinned American economic strength, sustained national security, and reinforced the nation's global standing. That position now faces a defining test as the next generation of advanced technologies emerges at the intersection of software, hardware, and manufacturing. Today, U.S. leadership is increasingly at risk in one of the most consequential technology domains of the twenty-first century, with direct implications for economic competitiveness, workforce resilience, and national security: advanced robotics and physical artificial intelligence.

Advanced robotics, physical platforms capable of perceiving their environment, making decisions, and performing tasks with varying levels of autonomy, are rapidly reshaping our world; from the battlefield to most every aspect of the modern economy.[1] Paired with parallel advances in artificial intelligence, sensing, and compute, robotics systems are rapidly advancing in complexity and capability; becoming foundational infrastructure for modern economies and future military operations. This technological revolution is progressing around the world, with allies and adversaries alike moving rapidly to adopt robotics programs and scale manufacturing capacity. The United States' ability to move with speed and compete on a level playing field in the robotics industry will define the next era of national competitiveness, both in economic and national security contexts

In advanced robotics, we are witnessing a similar set of circumstances play out which hobbled U.S. leadership in the small uncrewed aircraft systems (UAS, or drone) sector.[2] As with drones, the People's Republic of China (PRC) has designated robotics a national strategic priority and mobilized massive state resources, subsidies, preferential financing, coordinated industrial policy, and military-civil fusion mechanisms, to scale domestic champions and shape global markets. As a result, Chinese robotics firms are rapidly producing at extraordinary speed, flooding global markets, and consolidating not only their control of this new generation of advanced robotics but also the associated supply chains and technologies.

The experience of the drone sector provides a clear warning. In that market, sustained dumping by subsidized Chinese firms, combined with slow and fragmented policy responses in the U.S., resulted in overwhelming PRC market dominance, the erosion of domestic manufacturing capacity, and long-term dependence on adversary-linked supply chains. Robotics, even larger and more deeply embedded in the U.S. industrial base, cannot afford a similar outcome.[3]

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[1] AUVSI defines advanced robotics as: A physical platform capable of perceiving its environment, making decisions, and performing tasks with varying levels of autonomy—from commercial autonomous vehicles to a wide range of industrial and defense robotic platforms.

[2] AUVSI Partnership for Drone Competitiveness: White Paper (Arlington, VA: AUVSI, 2024), https://www.auvsi.org/auvsi-partnership-for-drone-competitiveness/

[3] Association for Uncrewed Vehicle Systems International (AUVSI), Partnership for Drone Competitiveness: White Paper (Arlington, VA: AUVSI, 2022), https://www.auvsi.org/auvsi-partnership-for-drone-competitiveness/.

Beyond the context of broader U.S.–China competition, advanced robotics present transformational societal benefit for the United States by driving productivity growth while improving the quality and sustainability of work. The robotics market is large, capital intensive, and deeply embedded across the industrial base, making delayed action far more costly to reverse. By enabling higher output, greater consistency, and more efficient use of labor, robotics help sustain economic performance amid tightening workforce and demographic constraints. Robotic systems also reduce exposure to hazardous, repetitive, and physically demanding tasks, lowering injury risk while allowing workers to focus on higher-value activities that require judgment, oversight, and adaptability. Critically, these productivity gains are occurring alongside, not in place of, the American workforce.

This whitepaper, produced as part of the Association for Uncrewed Vehicle Systems International (AUVSI)'s Partnership for Robotics Competitiveness, applies hard-learned lessons from the drone sector to robotics and physical AI. Drawing on the deep industry knowledge and expertise across AUVSI's membership, it outlines the competitive challenge posed by PRC state-backed robotics firms; details the national security, economic, and workforce risks of continued inaction; and proposes a measured, risk-based policy framework to level the playing field for U.S. and allied robotics manufacturers. Through this Partnership, AUVSI is convening industry, policymakers, and policymakers to help shape a coherent national approach to robotics and physical artificial intelligence.

Lessons from the Drone Sector

The evolution of the small UAS market offers a clear and cautionary case study for robotics and physical artificial intelligence. Through its *Partnership for Drone Competitiveness*, AUVSI documented how Chinese drone manufacturers leveraged sustained state subsidies, market dumping with aggressive below-cost pricing, preferential access to capital, and control over key components to achieve rapid global market dominance well before effective policy responses were in place.

As detailed in AUVSI's *Partnership for Drone Competitiveness* whitepaper, these dynamics produced predictable outcomes. U.S. and allied manufacturers, operating under market-based principles and facing an uneven competitive landscape created by a host of unfair market practices, faced eroding margins and declining investor confidence.[4] Private investment slowed, domestic production capacity migrated offshore, and reliance on PRC-linked supply chains deepened across both platforms and critical components. In the drone space, policymakers have begun to take action, such as to restrict procurement of certain PRC drones, but only after significant damage was inflicted on the U.S. industrial base, making recovery slow, costly, and incomplete.

The central lesson from the drone sector is that policy intervention can be effective, but timing and scope matter. Early targeted measures, focused on fair competition, supply-chain security, and domestic industrial capacity, are far more effective than reactive restrictions imposed after market dominance and dependency are already entrenched. Once ecosystems, standards, and supply chains consolidate around subsidized foreign platforms, reversing course becomes exponentially more difficult.

Robotics now sits at a similar inflection point. PRC state-backed firms are scaling rapidly, leveraging the same playbook of centrally planned unfair market practices as with the drone sector. This time, the stakes are even higher; robotics systems are deeply embedded across a massive range of applications ranging from manufacturing, agriculture, and logistics, to energy and national defense. Allowing comparable market capture in robotics would create dependencies far more pervasive and durable than those observed in the drone sector, with broader economic, workforce, and national-security consequences.

The *Partnership for Robotics Competitiveness* is therefore deliberately modeled on the lessons of the drone experience. It seeks to apply those insights earlier in the lifecycle of an industry that is larger, more capital-intensive, and more deeply embedded in the U.S. industrial base. By acting now before market dominance hardens into structural dependence policymakers can avoid repeating the mistakes of the drone sector and ensure that robotics adoption strengthens U.S. competitiveness, workforce resilience, and national security rather than undermining them.

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[4] Ibid

Robotics and Physical AI as Strategic Technologies

Robotics is entering a period of accelerated transformation driven by advances in artificial intelligence, machine learning, sensing, and compute. Earlier generations of industrial robots were largely pre-programmed, rigid, and confined to structured environments such as automotive assembly lines. Modern systems, by contrast, increasingly operate autonomously in dynamic, unstructured settings, navigating warehouses, farms, city streets, and disaster zones.

This shift reflects a broader evolution from task-specific automation toward generalizable embodied intelligence. Robots are no longer simply executing scripts; they are perceiving complex environments, learning from data, and adapting behavior in real time. Advances in foundation models, reinforcement learning, and other complementary technologies are accelerating this trend, enabling robots to perform tasks once thought to require human assistance.[5]

Robotics Are Crucial to U.S. Economic Competitiveness

As adoption accelerates, robotics will play a central role in addressing labor shortages, increasing productivity, and sustaining U.S. economic growth. At the same time, robotics platforms are becoming integral to military logistics and future operational concepts, making leadership in this domain a strategic imperative.

Robotics systems are inherently dual use. The same autonomy stacks, sensors, actuators, and control software that enable warehouse automation and industrial efficiency can be adapted for military logistics, intelligence, surveillance, reconnaissance, and battlefield support functions. This dual-use character places robotics alongside semiconductors, aerospace, and advanced manufacturing as technology domains where economic competitiveness and national security are inseparable.

Unlike purely digital technologies, robotics platforms are deployed directly into the physical world, often in sensitive or safety-critical environments. As a result, leadership in robotics confers advantages not only in productivity and economic growth, but also in operational resilience, military sustainment, and strategic deterrence.

Strategic leadership in robotics will therefore shape not only industrial productivity, but also military capability, alliance structures, and geopolitical influence. Nations that control robotics platforms, standards, and supply chains will exert disproportionate leverage over the future of work and warfare.

Applications now span several critical industries:

- **Manufacturing and Warehousing:** Autonomous mobile robots (AMRs) are growing rapidly in industrial environments, representing a core component of flexible automation in warehouses and manufacturing facilities. The global AMR market size was estimated at $4.74 billion in 2025 driven by rising demand for automated internal logistics, material handling, and efficiency gains in manufacturing and fulfillment

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[5] Deloitte, "Physical AI and humanoid robots: The future of adaptive robotics," Dec. 10, 2025, https://www.deloitte.com/us/en/insights/topics/technology-management/tech-trends/2026/physical-ai-humanoid-robots.html

operations.[6] AMR deployments reduce reliance on manual transport labor and help streamline internal material flows, improving both throughput and operational flexibility in high-volume industrial settings. These capabilities are increasingly central to U.S.-China competitiveness: they help offset labor constraints, reduce unit costs, and shorten changeover times while supporting a resilient industrial base for critical goods. For national security, broadly deployed factory and warehouse automation strengthens surge capacity and sustainment for defense-relevant production and spare-parts logistics, reducing exposure to disruptions or adversary leverage in upstream supply chains.

- **Logistics and Delivery:** Autonomous forklifts, yard-automation systems, and delivery robots are being deployed at scale to improve speed, safety, and reliability across distribution networks. From a competitiveness lens, logistics automation is a force multiplier for U.S. manufacturing and e-commerce, cutting dwell time, reducing damage and shrink, and improving inventory accuracy. [7] It also has clear national-security relevance: automated yards and warehouses harden domestic distribution and mobilization capacity, improve continuity of operations during disruptions, and reduce single-point vulnerabilities in critical supply and sustainment chains.
- **Agriculture and Natural Resources:** Robotics-enabled precision agriculture, such as autonomous harvesting, targeted spraying, and real-time field monitoring, is already improving yields and input efficiency while reducing farmers' exposure to hazardous conditions. In the United States, initiatives such as Grand Farm in North Dakota demonstrate the tremendous potential of these technologies that, if deployed at scale would address labor shortages, increase productivity, and improve resilience in food production.[8] To state the obvious, food security is national security. Robotic technologies will enable farmers to feed America for generations to come, and it is crucial that the technologies we use to do so are not using platforms and components from foreign adversary-linked firms.
- **Public Safety and Emergency Response:** Search-and-rescue robots, disaster-response platforms, and hazardous-material handling systems extend first responders' reach and reduce risk to personnel in dangerous environments.[9] These systems support national resilience by improving response speed and situational awareness during hurricanes, wildfires, industrial accidents, and other crises as well as day-to-day public safety operations in a variety of settings. However, given the interconnected nature of these systems, if allowed to be adopted at scale in the United States, foreign adversary-made robotics in public safety and security could pose a significant national security and public risk by undermining emergency response operations, exposing sensitive data, or disrupting critical public safety functions when they are needed most.

Robotics as a Workforce Enabler

Robotics and physical artificial intelligence are not a substitute for the American workforce; they are increasingly essential to sustaining it. Across advanced economies, employers face persistent labor shortages,

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[6] Grand View Research. *Autonomous Mobile Robots Market Size, Share & Trends Analysis Report by Component, By Application (Manufacturing & Warehouse, Logistics), By Region, And Segment Forecasts, 2025 - 2033*. 2025. https://www.grandviewresearch.com/industry-analysis/autonomous-mobile-robots-market

[7] Deloitte, "Using autonomous robots to drive supply chain innovation," Deloitte Insights (Mar. 2025), https://www.deloitte.com/us/en/Industries/industrial-construction/articles/autonomous-robots-supply-chain-innovation.html

[8] Grand Farm, "About Grand Farm," 2024. https://grandfarm.com/about/

[9] U.S. Department of Homeland Security, Science and Technology Directorate, *Multifunctional Unmanned Ground Vehicles for Emergency Response* (Washington, DC: Department of Homeland Security, May 20, 2025), https://www.dhs.gov/sites/default/files/2025-05/25_0520_st_mugvmsr.pdf

demographic headwinds, and rising productivity demands that cannot be met through workforce supply alone. Recent global labor-market analysis finds that automation and robotics are being adopted primarily as labor-augmenting technologies; tools which enable firms to maintain output, improve job quality, and sustain economic growth amid tightening labor markets.[10]

Across manufacturing, logistics, agriculture, energy, and public services, structural labor constraints continue to limit hiring, particularly in physically demanding and safety-critical roles. Robotics systems help address these challenges by performing repetitive, hazardous, or physically strenuous tasks while enabling workers to focus on higher-value functions such as system oversight, diagnostics, and maintenance.[11] Rather than displacing jobs, or reducing the need for workers, robotics will reshape work, redistributing tasks in ways that ease physical strain, improve job quality, and enable existing teams to operate more efficiently under tight labor conditions.[12]

In manufacturing and warehousing, collaborative robots (cobots) and autonomous mobile robots allow facilities to sustain throughput and reliability despite constrained hiring pools, with industry surveys showing that firms increasingly view automation as a necessary response to skilled-labor shortages rather than a substitute for workers.[13]

Robotics also poses significant benefits in occupational safety and worker health. Robots are increasingly deployed to reduce worker exposure to heavy lifting, repetitive motion, confined spaces, extreme temperatures, and hazardous materials. CDC research, as part of its Future of Work program, confirms that these technologies can meaningfully reduce injury-prone activities and support longer, healthier working lives, an increasingly important consideration as the workforce ages.[14] These safety gains translate into reduced lost-time incidents, lower healthcare and insurance costs, and improved workforce retention.

Realizing these workforce benefits depends on sustained investment in workforce readiness and trust. As robotics adoption accelerates, demand will continue to grow for skilled workers capable of deploying, operating, and maintaining complex systems. Integrating robotics policy with workforce development through industry-aligned skills, accessible training pathways, and safe deployment environments is essential to ensuring that productivity gains translate into durable job quality and long-term labor-market stability.

Robotics, Competitiveness, and the Future of American Industry

As global competitors accelerate deployment of advanced robotics to offset labor shortages, lower production costs, and preserve industrial scale, American economic competitiveness rests on the ability to also do so at a

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[10] World Economic Forum. *The Future of Jobs Report 2025*. Geneva: World Economic Forum, 2025. https://www.weforum.org/reports/the-future-of-jobs-report-2025/

[11] U.S. Bureau of Labor Statistics. *Assessing the Impact of New Technologies on the Labor Market*. Congressional Report. Washington, DC: U.S. Department of Labor, 2024–2025. https://www.bls.gov/bls/congressional-reports/assessing-the-impact-of-new-technologies-on-the-labor-market.htm

[12] Learning and Work Institute / Learning & Work Foundation. *Emerging Technologies and the Labour Market: Evidence Briefing*. London: Learning & Work Foundation, August 2025. https://www.lrfoundation.org.uk/sites/default/files/2025-08/emerging-tech-briefing-final.pdf

[13] Deloitte. *2025 Smart Manufacturing and Operations Survey*. May 2025. https://www.deloitte.com/us/en/insights/industry/manufacturing/2025-smart-manufacturing-survey.html

[14] National Institute for Occupational Safety and Health (NIOSH), "About the Future of Work Initiative," Centers for Disease Control and Prevention, accessed January 2026, https://www.cdc.gov/niosh/future-of-work/about/

greater or comparable pace. Failure to do so risks not just America's economic and industrial competitiveness overall, but also the countless jobs which are predicated on that competitiveness.

This contrast is increasingly evident in China, where robotics and embodied artificial intelligence are being deployed deliberately at the core of the PRC's economic strategy, to sustain manufacturing competitiveness, preserve industrial capacity, and mitigate the effects of demographic decline and rising labor costs.[15] Through coordinated state investment and rapid adoption across industrial sectors, China is treating robotics as a foundational pillar of its economic and social future. Absent a coordinated U.S. response, slower or uneven adoption risks pushing production, and the skilled jobs that accompany it, toward countries that do successfully adopt and scale this critical technology. Through proactive and comprehensive action, government action can drive robotics not as a substitute for labor, but as a force multiplier for American workers, and as a foundation for sustained leadership in the global economy.

[15] Carnegie Endowment for International Peace, *Embodied AI: China's Big Bet on Smart Robots* (November 2025), https://carnegieendowment.org/research/2025/11/embodied-ai-china-smart-robots

Robotics and National Security and Defense

Robotics and the Modern Battlefield

Autonomous systems for logistics, resupply, reconnaissance, and battlefield support are increasingly central to operating in contested environments and reducing risk to service members. Across the defense ecosystem, advances in autonomy software, simulation, and ground systems enabling faster testing, validation, and deployment of capabilities that support maneuver, sustainment, and distribution under real-world conditions.

Beyond tactical advantages, these capabilities are becoming a strategic determinant in U.S.-China military competition, where robotics and autonomous systems are increasingly integrated into force development, training, and operational concepts. China's military has moved well beyond experimentation, incorporating uncrewed ground systems into military exercises and combined-arms scenarios as part of a broader effort to modernize forces and enhance operational flexibility.[16]

Recent demonstrations of LiDAR-equipped robotic ground platforms operating in amphibious assault exercises further underscore an emphasis on autonomy for reconnaissance, perimeter security, and force protection in complex, contested environments.[17] This demonstrates clearly that maintaining strategic parity in robotics and autonomy is now a core defense imperative for China; heightening the importance of sustained U.S. investment, trusted supply chains, and secure integration across defense-relevant robotic technologies in order to maintain parity.

The ongoing conflict in Ukraine has made clear that robotics and autonomy are no longer experimental additions to military operations but foundational elements reshaping how wars are fought and sustained. The widespread use of uncrewed systems for reconnaissance, logistics, targeting, and force protection has demonstrated how autonomous platforms can extend reach, increase persistence, and reduce risk to personnel in highly contested environments. Just as importantly, these systems have shown how rapidly adaptable, attritable technologies can offset conventional advantages in mass, armor, and firepower.

These battlefield lessons are being closely studied by U.S. competitors. China, in particular, has treated recent combat experience as a proving ground for its long-standing emphasis on "intelligentized warfare," accelerating efforts to integrate robotics, autonomy, and AI-enabled decision-making across its force structure. Chinese military planners increasingly see robotics as essential to distributed operations, sustained tempo, and operational flexibility, especially in scenarios where communications are degraded and human exposure carries heightened risk.[18]

This convergence of real-world combat experience and strategic adaptation underscores a broader shift in military competition. The ability to design, produce, and integrate robotic systems at scale, drawing from both defense and commercial technology ecosystems, is becoming a decisive determinant of military power. As autonomous systems move from augmentation to integration across doctrine, training, and operations,

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[16] Elaine Dezenski, "Beijing's Robot Army Isn't Science Fiction – It's Already Here," *American Enterprise Institute*, https://www.aei.org/op-eds/beijings-robot-army-isnt-science-fiction-its-already-here/

[17] *Foundation for Defense of Democracies*, "State Television Shows Chinese Military Using LiDAR-Equipped Robotic Wolves During Amphibious Assault Exercises," November 19, 2025, https://www.fdd.org/analysis/2025/11/19/state-television-shows-chinese-military-using-lidar-equipped-robotic-wolves-during-amphibious-assault-exercises/

[18] Jamestown Foundation, "Autonomous Battlefield: PLA Lessons from Russia's Invasion of Ukraine," *China Brief*, 2024, https://jamestown.org/autonomous-battlefield-pla-lessons-from-russias-invasion-of-ukraine/

maintaining leadership in robotics and autonomy robust action to ensure U.S. capability in this space is a crucial prerequisite for preserving battlefield advantage and long-term strategic stability in an era of great-power competition.[19]

Connected Systems and Cyber-Physical Risk

Modern robotic systems are inherently networked cyber-physical systems (CPS) that combine software, communications, and physical machines in ways that link digital systems directly to real-world action. Industrial, service, and autonomous robots increasingly rely on cloud connectivity, remote monitoring, software updates delivered over the air, and continuous data collection to support performance improvement, predictive maintenance, and adaptive learning. These capabilities create broad attack surfaces where weaknesses in software, network connections, and data management can be exploited to compromise both information and physical operations.[20] In practical terms, cyber-physical risk creates three concerns: data exposure, remote disruption of physical systems, and long-term dependence on adversary linked update pathways.

The operational data generated by robotics systems, including detailed maps of facilities, records of movement and tasks, environmental sensing, and logs of human-machine interactions is sensitive information that requires protecting. Over time, aggregated system data can reveal commercially sensitive information, production patterns, operational dependencies, and insights into critical infrastructure activities that are valuable to competitors and potential adversaries alike. Attacks that target system data or control interfaces can therefore result not only in data exposure, but also in serious physical disruption, or unauthorized observation, blurring the line between cyber intrusion and real-world consequence.

Recent high-profile cases illustrate these risks in concrete terms. Security researchers disclosed a critical backdoor in Unitree's Go1 quadruped that allowed remote access to live camera feeds and control functions without user authorization, highlighting how hidden software vulnerabilities can enable covert surveillance and system takeover.[21] Similarly, PRC-made LiDAR sensors, now widely embedded in autonomous vehicles, mapping systems, and critical infrastructure, have prompted significant security concerns, including legislative efforts to remedy the threat.[22], [23]

Investigative reporting on a U.S.-based self-driving truck company revealed how sensitive autonomous driving technology and related operational data were shared with Chinese partners despite a U.S. national security agreement, underscoring the difficulty of protecting safety-critical systems and proprietary data in globally connected robotics ecosystems.[24] More broadly, the case illustrates how foreign adversary-linked ownership structures, development partnerships, and component dependencies can create persistent structural vulnerabilities in robotics and autonomous systems. When core hardware, software, or corporate control is tied

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[19] Ibid

[20] National Institute of Standards and Technology (NIST), *Cyber-Physical Systems Program*, U.S. Department of Commerce, https://www.nist.gov/el/cyber-physical-systems.

[21] Dave Lawler, "Threat Spotlight: Backdoor Found in Chinese Robots," *Axios*, April 1, 2025, https://www.axios.com/2025/04/01/threat-spotlight-backdoor-in-chinese-robots-future-of-cybersecurity

[22] *Policy Alert: Urgent U.S. Response Needed to Counter China's Strategic Use of LiDAR Technology*, Foundation for Defense of Democracies (FDD Action), September 23, 2025 FDD Action

[23] Representative Dusty Johnson (R-SD), "Johnson Safeguards U.S. Infrastructure from Chinese Spy Technology," press release, July 30, 2025, https://dustyjohnson.house.gov/media/press-releases/johnson-safeguards-us-infrastructure-chinese-spy-technology

[24] Rebecca Elliott and Jon Emont, "The Self-Driving Truck Startup That Siphoned Trade Secrets to China," *Wall Street Journal*, May 27, 2025, https://www.wsj.com/tech/china-self-driving-trucks-tusimple-c20255e1

to adversarial jurisdictions, technical safeguards and contractual protections offer limited assurance, as influence over system design, update pathways, and data access can be exercised indirectly through supply-chain position and ownership leverage.

These cyber-physical risks must also be understood in the context of the PRC domestic legal and regulatory framework. China's National Intelligence Law, Cybersecurity Law, Data Security Law, and Personal Information Protection Law collectively establish a legal environment in which commercial technology firms are obligated to support state intelligence and security objectives and provide access to data, systems, and technical capabilities upon request.[25] In the context of networked robotics systems, where cloud services, remote access, software updates, and continuous data collection are core operational features, these authorities create a structural pathway for state access to cyber-physical systems and their associated data, regardless of corporate structure or contractual assurances made to foreign customers.

In practical terms, this means that vulnerabilities in robotic CPS are not merely technical risks, but jurisdictional and geopolitical risks. Operational data collected by Chinese-linked robotics platforms, including facility layouts, sensor feeds, system controls, and performance records, can be rendered legally accessible to the Chinese state by design. As a result, cyber-physical exposure in robotics cannot be treated as neutral or symmetric across suppliers. Instead, it reflects a fundamental asymmetry in legal obligations, where Chinese firms operate under statutory mandates to share data with state authorities, while foreign competitors remain bound by market-based compliance regimes and democratic privacy and security norms.

Without these layered protections, interconnected robotics systems can serve as gateways into broader enterprise and operational networks, enabling unauthorized data access, operational disruption, compromised safety environments, and systemic exposure across critical sectors. Addressing cyber-physical risk in robotics therefore requires coordinated government-industry risk management, adoption of CPS-specific standards, investment in secure-by-design systems, and cross-sector collaboration to safeguard operational resilience, economic competitiveness, and national security as robotics becomes more deeply embedded across the U.S. economy.

As connected robotic systems proliferate across manufacturing, logistics, healthcare, and public infrastructure, vulnerabilities in software, data flows, and remote access pathways increasingly carry implications that extend beyond individual firms to the broader economic and security environment. When combined with the supply chain concentration and market control dynamics outlined elsewhere in this document, cyber-physical risk further heightens the stakes, reinforcing that these exposures are not isolated technical issues but structural challenges with strategic consequences. Managing these risks will require more than incremental improvements in cybersecurity practices; it will demand sustained public policy attention to how robotics systems are designed, deployed, governed, and sourced, with a focus on safeguarding sensitive operational data, ensuring system integrity, and reducing structural exposure to adversary-linked technologies.

[25] Chun Han Wong, "China Adopts Sweeping National-Security Law," *Wall Street Journal*, July 1, 2015, https://www.wsj.com/articles/china-adopts-sweeping-national-security-law-1435757589

The PRC's Whole-of-Nation Strategy to Dominate Robotics

The PRC has identified robotics as a cornerstone of its long-term industrial and geopolitical strategy; viewing the sector as essential to national power, technological dominance, and global competitiveness.[26] Across successive industrial policy frameworks, such as Made in China 2025, multiple Five-Year Plans, and sector-specific action programs, Beijing has pursued a coordinated, whole-of-nation effort to achieve leadership across the full robotics tech stack. This approach emphasizes control over critical components, manufacturing equipment, automation technologies, and system integration, reflecting a strategic intent to translate advances in robotics into economic leverage, military capability, and geopolitical influence. Within this policy architecture, robotics is positioned alongside other top-tier priority technologies such as semiconductors, artificial intelligence, electric vehicles, and advanced materials, underscoring its central role in China's broader competition with the United States. [27, 28]

Policy tools deployed in support of robotics include direct subsidies and grants; preferential access to low-cost capital through state-owned banks and guidance funds; mandated localization and domestic-sourcing requirements; coordinated R&D across universities, state laboratories, and industry; preferential procurement by state-owned enterprises and local governments; and explicit integration with military-civil fusion objectives.[29,]

In parallel with these domestic policy tools, China has pursued a deliberate "go out" and "bring in" strategy to accelerate the development of its robotics sector by leveraging global markets. This strategy, closely aligned with Made in China 2025 and subsequent industrial plans, reflect Beijing's substantive efforts to advance strategic industrial objectives as a means for national geopolitical power.[30] Under this approach, Chinese firms are encouraged to acquire or invest in or acquire foreign robotics and automation companies, while simultaneously absorbing foreign technology, talent, and operational know-how into domestic ecosystems through joint ventures, partnerships, and localization requirements.

High-profile acquisitions in the robotics and automation space, such as the German industrial robotics company Kuka, illustrate how outbound investment has been used to gain access to advanced manufacturing capabilities, system integration expertise, and global customer networks, while inward policies ensure that these capabilities are internalized within China's domestic industrial base.[31] Together, China's outward investment and inward technology-absorption strategies have enabled rapid learning, shortened development

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[26] Sunny Cheung, *Testimony Before the U.S.-China Economic and Security Review Commission's Hearing, "Made in China 2025—Who Is Winning?"* (Feb. 6, 2025), The Jamestown Foundation, 2 pp., U.S.-China Economic and Security Review Commission, https://www.uscc.gov/sites/default/files/2025-02/Sunny_Cheung_Testimony.pdf
[27] Ibid
[28] Congressional Research Service, "'Made in China 2025' Industrial Policies: Issues for Congress," IF10964 (updated December 12, 2024), https://www.congress.gov/crs-product/IF10964
[29] Jamestown Foundation, "*Embodied Intelligence: The PRC's Whole-of-Nation Push into Robotics*," *China Brief*, Jamestown Foundation (2024), https://jamestown.org/embodied-intelligence-the-prcs-whole-of-nation-push-into-robotics/

[30] U.S.-China Economic and Security Review Commission, *Made in China 2025: Evaluating China's Performance*. https://www.uscc.gov/research/made-china-2025-evaluating-chinas-performance
[31] U.S.-China Economic and Security Review Commission, *Made in China 2025: Evaluating China's Performance*, section "Outbound Investment and Technology Acquisition," https://www.uscc.gov/research/made-china-2025-evaluating-chinas-performance#_Toc213921797

timelines, and repositioned Chinese firms higher in the global robotics value chain.[32] From a U.S. competitiveness perspective, this model underscores how Chinese industrial policy extends beyond subsidies and finance to shape global competition, raising concerns around technology transfer, supply-chain dependencies, and the long-term erosion of U.S. and allied leadership in advanced robotics.

In addition to the dynamics described above, China's intelligence, cybersecurity, and data governance laws serve as an explicit legal lever to institutionalize civil-military fusion and enable unfair market practices by the PRC. These statutes codify state authority over commercial actors, ensuring that global market participation, technological development, and data generation directly advance state and military objectives:

- China's **National Intelligence Law (2017)** obligates all organizations and citizens to "support, assist, and cooperate" with national intelligence work and to maintain secrecy regarding such cooperation, eliminating any meaningful legal separation between private enterprise and the state.[33] This mandate ensures that intellectual property, technical expertise, and operational insights gained through commercial activity, including overseas investment, joint ventures, and exports, remain legally accessible for state and military use.
- China's **Cybersecurity Law (2016)** and **Data Security Law (2021)** reinforce this framework by asserting sweeping state authority over networked systems, industrial software, and data flows. The Cybersecurity Law authorizes security reviews, technical access requirements, and mandatory cooperation for operators of networked and "critical information infrastructure," while the Data Security Law establishes a national-security-based data classification regime that places broad categories of industrial and operational data under government control.[34], [35] In sectors such as robotics, autonomy, and advanced manufacturing, where software updates, telemetry, and operational data are integral, these authorities function as structural advantages for Chinese firms, enabling state-directed learning while imposing asymmetric compliance burdens and exposure risks on foreign competitors.
- The **Personal Information Protection Law (2021)** further entrenches this asymmetry. Although often presented as a privacy regime aligned with international norms, the law contains expansive carve-outs for national security, public security, and intelligence activities, explicitly preserving state access to data collected by private firms.[36] Rather than constraining government power, the Personal Information Protection Law formalizes the primacy of state interests over personal and industrial data, allowing Chinese firms to market themselves abroad as privacy-compliant while remaining legally bound to support state objectives domestically.[37]

Together, these tools have allowed China to quickly build its robotics sector into a dominant global player; allowing Chinese robotics firms to leverage open international markets, absorb foreign technology and data, and scale rapidly

[32] Jamestown Foundation, "Destination Unknown: Investment in China's 'Go Out' Policy," https://jamestown.org/program/destination-unknown-investment-in-chinas-go-out-policy/
[33] People's Republic of China, *National Intelligence Law* (2017), https://www.chinalawtranslate.com/en/national-intelligence-law-of-the-p-r-c-2017/
[34] People's Republic of China, *Cybersecurity Law* (2016), https://www.chinalawtranslate.com/en/2016-cybersecurity-law/
[35] People's Republic of China, *Data Security Law* (2021), https://www.chinalawtranslate.com/en/2021-data-security-law/
[36] People's Republic of China, *Personal Information Protection Law* (2021), https://www.chinalawtranslate.com/en/2021-personal-information-protection-law/
[37] Ibid

This state-backed growth model has enabled Chinese firms to compete aggressively on price, supported by extensive subsidies, preferential financing, and tolerance for prolonged losses, distorting global competition and placing U.S. and allied manufacturers operating under market-based constraints at a structural disadvantage.[38]

Supply-Chain Control as Strategic Leverage

Robotics systems depend on complex, multi-tiered supply chains including rare-earth magnets, electric motors, precision actuators, batteries, power electronics, sensors, cameras, and embedded compute. Through decades of concerted effort via the government policy levers described earlier in this document, the PRC has amassed outsized control over several critical robotics inputs. These supply chain dynamics affect state manufacturing strategy, site selection, and incentive design. Beyond providing the PRC with a highly insulated supply chain, this also constitutes a significant instrument of state power, which the PRC wields as a soft power cudgel to advance its interests. This represents a durable element of PRC soft power that is difficult to address: many of these inputs are capital-intensive, difficult to substitute, and characterized by long development and qualification cycles. As a consequence, adapting to PRC dominance in aspects of the robotics supply chain will require concerted and coordinated efforts to address.

Advanced robotics platforms integrate dozens, often hundreds, of specialized components whose availability, quality, and security directly determine system performance. Unlike software-centric artificial intelligence, robotics systems cannot simply "swap suppliers" without extensive redesign, recertification, and performance tradeoffs.[39]

Rare Earth Elements and Permanent Magnets

High-performance electric motors and actuators rely on rare-earth permanent magnets, particularly neodymium-iron-boron (NdFeB), which are foundational to modern robotics, electric vehicles, and advanced defense systems. As the Bureau of Industry and Security (BIS) notes in its Section 232 investigation into the Effect of Imports of Neodymium-Iron-Boron, "NdFeB magnets are the strongest permanent magnets commercially available and improve the efficiency of electrical machines…" making them indispensable for applications requiring high torque density, compact form factors, and sustained performance under demanding conditions.[40] These attributes are especially critical for robotic platforms, where motor efficiency and power density directly shape payload capacity, endurance, and system reliability.

While rare-earth elements are mined in multiple countries, the PRC has consolidated dominant control over downstream refining, alloying, and magnet manufacturing, creating a strategic chokepoint in the supply chain. Department of Commerce BIS's 232 investigation on this subject found that the United States has *"extremely limited capacity to manufacture NdFeB magnets and is nearly one hundred percent dependent on imports to*

[38] House Select Committee on the Chinese Communist Party.
Reset, Prevent, Build: A Strategy to Win America's Economic Competition with the CCP.
Washington, DC: U.S. House of Representatives, 2024.
HRPT-118-3.pdf

[39] BCG and World Economic Forum, *Physical AI*,
https://reports.weforum.org/docs/WEF_Physical_AI_Powering_the_New_Age_of_Industrial_Operations_2025.pdf

[40] U.S. Department of Commerce, Bureau of Industry and Security, *Section 232 Investigation into the Effect of Imports of Neodymium-Iron-Boron (NdFeB) Permanent Magnets on the National Security: Report Appendices* (Washington, DC, 2025), https://media.bis.gov/media/documents/section-232-ndfeb-magnets-report-appendices-combined.pdf

meet commercial and defense requirements," with the majority of those imports originating from China.[41] This concentration amplifies economic and national-security risk, particularly as demand for advanced robotics and physical-AI systems accelerates.

Critically, permanent magnets are not easily substitutable without meaningful performance penalties. This investigation emphasized that sintered NdFeB magnets dominate the global market precisely because of their superior magnetic strength and thermal performance, noting that they are *"less easily substituted for than their bonded counterparts"* and essential for high-temperature and high-performance applications.[42] Substituting alternative magnet materials has a knock-on effect in the highly-specialized, highly calibrated applications demanded by advanced robotic systems where reduced torque density, lower efficiency, and diminished durability would necessitate total redesign or acceptance of tradeoffs undermining operational lifetime and effectiveness in both commercial and defense-relevant robotic systems.

Batteries and Power Electronics

Advanced batteries and power-management electronics constitute another strategic chokepoint for mobile robotics and humanoid platforms, directly constraining system performance, endurance, and operational viability. While the components of batteries themselves are critical and merit consideration, battery systems are not simply the components they comprise but complex, tightly integrated assemblies in which cell chemistry, design, battery-management systems, and power electronics must be engineered together to meet performance, safety, and reliability requirements.[43] This tight coupling ties battery selection and power-delivery architecture directly to platform-level tradeoffs in energy density, power output, and duty cycle, making energy systems a foundational design constraint rather than a modular input.

These technical realities intersect with a highly concentrated global supply chain. Congressional and executive-branch analyses find that China dominates key downstream stages of the lithium-ion battery ecosystem, including processing, cell manufacturing, and battery-grade component production; creating structural dependencies for advanced manufacturing sectors that rely on high-performance batteries.[44], [45] Independent research and market analysis further show that Chinese industrial policy and regulatory actions can rapidly reshape battery availability, pricing, and trade flows, reinforcing the strategic leverage associated with downstream control of battery supply chains.[46], [47] In the context of U.S.-China technological competition, dominance over battery supply chains thus represents a durable form of industrial and geopolitical leverage which directly shapes the future viability of mobile robotics and embodied AI systems.

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[41] Ibid.
[42] Ibid
[43] Kleinman Center for Energy Policy, *Battling for Batteries: Li-Ion Policy and Supply Chain Dynamics in the U.S. and China* (Philadelphia: University of Pennsylvania, 2024), https://kleinmanenergy.upenn.edu/research/publications/battling-for-batteries-li-ion-policy-and-supply-chain-dynamics-in-the-u-s-and-china/.
[44] Congressional Research Service, *Advanced Lithium-Ion Energy Storage Battery Manufacturing in the United States*, R48538 (Washington, DC: Congressional Research Service, May 9, 2025), https://www.congress.gov/crs_external_products/R/PDF/R48538/R48538.4.pdf
[45] U.S. Energy Information Administration, "China dominates global battery manufacturing capacity," *Today in Energy*, March 2025, https://www.eia.gov/todayinenergy/detail.php?id=65305
[46] S&P Global Ratings, "Battery Brief: New China Rules to Upset Supply Chains," 2025, https://www.spglobal.com/ratings/en/regulatory/article/battery-brief-new-china-rules-to-upset-supply-chains-s101650821
[47] Department of Energy, *Four-Year Review of Supply Chains for the Advanced Batteries Sector* (Washington, DC: U.S. Department of Energy, 2024), https://www.energy.gov/sites/default/files/2024-12/20212024-Four%20Year%20Review%20of%20Supply%20Chains%20for%20the%20Advanced%20Batteries%20Sector.pdf

Sensors and LiDAR
Advanced sensing systems, particularly LiDAR, constitute another strategic chokepoint for modern robotics platforms, directly shaping perception, autonomy, and operational safety. Mobile robots, autonomous vehicles, and humanoid platforms depend on integrated sensing suites that include cameras, radar, and LiDAR to navigate complex environments and operate safely alongside people and infrastructure. LiDAR is especially consequential because it produces precise, three-dimensional representations of physical environments that underpin localization, mapping, obstacle detection, and coordinated autonomous behavior.[48]

From a strategic standpoint, LiDAR has become a focal technology within the PRC's civil-military fusion framework. As one recent assessment observes, LiDAR now sits "at the core of China's military modernization," reflecting Beijing's early recognition of the technology's value for autonomous platforms, intelligence collection, and battlefield awareness.[49] The same analysis emphasizes that PRC policy has deliberately blurred civilian and military applications, enabling LiDAR systems developed for commercial uses, such as autonomous vehicles and robotics, to transition rapidly into defense and security contexts.[50]

This strategic intent has been reinforced by sustained support by the PRC as a national project. Congressional analysis documents that the PRC has used subsidies, preferential procurement, and vertically integrated manufacturing ecosystems to scale domestic LiDAR production and undercut foreign competitors.[51] The U.S.–China Economic and Security Review Commission notes that Chinese firms have benefited from "state support and industrial policy that have enabled rapid scaling and cost advantages in advanced sensor technologies," including LiDAR systems used in automotive, robotics, and smart-infrastructure applications.[52] As a result, PRC manufacturers have captured a growing share of global LiDAR markets, positioning sensing technologies as another domain in which China has translated industrial policy into durable upstream control.

The nature of LiDAR data further heightens the strategic risk. Because LiDAR systems continuously collect detailed spatial and structural information, their deployment in factories, ports, warehouses, transportation hubs, energy facilities, or defense-adjacent sites can result in the creation of highly sensitive digital maps of critical infrastructure. Analysis warns that LiDAR embedded across civilian networks can generate persistent environmental awareness with clear intelligence and military utility, particularly where firmware, software updates, or data pathways remain subject to foreign influence or control.[53]

Once integrated into robotic platforms and infrastructure environments, LiDAR systems are difficult to replace without system-level recalibration, software retraining, and operational recertification.[54] These integration costs reinforce long-term dependence on upstream sensor suppliers and associated software ecosystems.

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[48] Bradley Bowman and Mark Montgomery, "*From Parade to Battlefield: LiDAR at the Core of China's Military Modernization*," *Foundation for Defense of Democracies*, September 22, 2025, https://www.fdd.org/analysis/2025/09/22/from-parade-to-battlefield-lidar-at-the-core-of-chinas-military-modernization/
[49] Ibid.
[50] Ibid.
[51] U.S.–China Economic and Security Review Commission, *2024 Annual Report to Congress* (Washington, DC: USCC, 2024), sections on advanced sensors and autonomous systems, https://www.uscc.gov/annual-report/2024-annual-report-congress
[52] Ibid.
[53] Bradley Bowman and Mark Montgomery, "*From Parade to Battlefield: LiDAR at the Core of China's Military Modernization*," *Foundation for Defense of Democracies*, September 22, 2025, https://www.fdd.org/analysis/2025/09/22/from-parade-to-battlefield-lidar-at-the-core-of-chinas-military-modernization/
[54] Ibid.

Taken together, the combination of industrial concentration, dual-use functionality, and sensitive data generation elevates LiDAR from a performance-critical component to a strategic chokepoint, one where dominance in manufacturing and deployment can translate into economic leverage, intelligence advantage, and military relevance in the context of U.S.-China technological competition.

Strategic Implications

Component chokepoints can be used to sustain price pressure, shape standards, create hidden dependencies, and exert geopolitical leverage.[55] As the U.S.-China Economic and Security Review Commission has cautioned in its 2025 report to Congress, Beijing increasingly treats supply chains as tools to advance their own interests, using dominance in critical industrial inputs to embed structural dependencies that can be exploited for geopolitical effect.[56] In their 2024 report to Congress, they stated that Chinese firms leveraged state support and vertically integrated supply chains to dominate commercial drone markets, embedding widespread reliance on PRC-manufactured components and quietly entrenching dominance.[57]

As AUVSI emphasized in comments submitted in response to the Department of Commerce BIS's Section 232 National Security Investigation of Imports of Robotics and Industrial Machinery, these dynamics are already materializing across the robotics ecosystem.[58, 59] Advanced robotics platforms are tightly integrated physical systems whose performance, safety, cybersecurity, and reliability are inseparable from the integrity of their underlying component supply chains. Dependence on concentrated or adversary-linked sources for critical inputs can undermine domestic industrial capacity even where final system integration occurs in the United States or allied countries, embedding structural vulnerabilities that are difficult to detect and even harder to unwind once systems are deployed at scale.

As noted earlier in this document, these structural vulnerabilities are further compounded by the PRC's demonstrated willingness to exploit supply-chain concentration through export controls and licensing regimes. Recent PRC export controls and licensing regimes for rare earths confirm Beijing's willingness to weaponize supply-chain dominance for geopolitical leverage, as noted by the House Select Committee on the Chinese Communist Party.[60], [61]Dependence on adversary-linked component and manufacturing ecosystems creates systemic vulnerability that market diversification alone cannot mitigate. Coordinated public policy, focused on

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[55] U.S.-China Economic and Security Review Commission, *2025 Annual Report to Congress* (Washington, DC: USCC, 2025), section titled "Chained to China: Beijing's Weaponization of Supply Chains," https://www.uscc.gov/annual-report/2025-annual-report-congress
[56] Ibid.
[57] U.S.-China Economic and Security Review Commission, *2024 Annual Report to Congress* (Washington, DC: USCC, 2024), sections on unmanned systems, electronics supply chains, and PRC industrial policy, https://www.uscc.gov/annual-report/2024-annual-report-congress
[58] Department of Commerce Bureau of Industry and Security, "Notice of Request for Public Comments on Section 232 National Security Investigation of Imports of Robotics and Industrial Machinery," *Federal Register* (September 26, 2025), https://www.federalregister.gov/documents/2025/09/26/2025-18749/notice-of-request-for-public-comments-on-section-232-national-security-investigation-of-imports-of
[59] Association for Uncrewed Vehicle Systems International (AUVSI), *Comments on the Department of Commerce Section 232 National Security Investigation of Imports of Robotics and Industrial Machinery* (submitted to the Bureau of Industry and Security, 2025).
[60] CNBC, "China Expands Rare-Earth Export Restrictions Ahead of Possible Trump-Xi Meeting," *CNBC*, October 9, 2025, https://www.cnbc.com/2025/10/09/china-expands-rare-earth-export-restrictions-ahead-of-possible-trump-xi-meeting.html
[61] House Select Committee on the Chinese Communist Party, "Moolenaar: China's Rare Earth Restrictions Are a Slap in the Face to President Trump," press release, October 2025, https://chinaselectcommittee.house.gov/media/press-releases/moolenaar-china-s-rare-earth-restrictions-are-a-slap-in-the-face-to-president-trump

domestic and allied production capacity, transparency into component provenance, and risk-based safeguards is therefore essential to strengthen resilience.

Humanoid Robotics as a case study of leading edge of Strategic and Technological Competition

Humanoid robotics has emerged as a central point of the PRC's industrial policy and strategic technology ambitions, reflecting Beijing's broader "whole-of-nation" approach to embodied intelligence. Chinese firms, backed by substantial central and local government funding, preferential procurement, and municipal incentive programs, are investing heavily in humanoid platforms designed for deployment across manufacturing, logistics, elder care, and service-sector applications.[62] National planning documents under China's 14th Five-Year Plan have codified robotics as strategic emerging industries, with special programs to promote PRC firms as national champions for robotics-related technologies. These policies set explicit growth targets and leadership objectives for China's robotics industry through 2025, reflecting the state's long-term commitment to accelerating its goals of technological and industrial hegemony.[63] PRC state efforts are taking a total approach to building out a national robotics industry, working to advance a full-stack oriented policy approach with efforts to drive advancements in all aspects of the tech stack.[64]

Building on this full-stack policy approach, PRC state efforts are increasingly focused on onshoring and consolidating control over the robotics supply chain as a matter of national competitiveness. As detailed by the Jamestown Foundation, Beijing is prioritizing domestic capabilities across both software and hardware layers of the robotics ecosystem, including operating systems, middleware, perception and control algorithms, sensors, actuators, and critical electromechanical components, reducing reliance on foreign inputs while strengthening industrial resilience.[65] Central and local government support, paired with coordinated industrial planning and targeted financing, has enabled Chinese firms to vertically integrate across the robotics value chain, align component development with system-level requirements, and scale production rapidly.[66]

This strategy mirrors earlier state-directed successes in sectors such as electric vehicles and batteries, where deep supply-chain localization translated manufacturing capacity into durable global competitive advantage.[67] In robotics, the emphasis on supply-chain dominance and domestic substitution serves not only economic objectives but strategic ones, positioning China to set technical standards, capture value across emerging physical-AI systems, and convert industrial depth into long-term technological and geopolitical leverage.[68]

While humanoid robotics does not encompass the full breadth of the robotics ecosystem, it functions as a high-visibility bellwether for who will control the foundational technologies, data, and manufacturing infrastructure

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[62] Jamestown Foundation, "*Embodied Intelligence: The PRC's Whole-of-Nation Push into Robotics*," *China Brief*, Jamestown Foundation (2024), https://jamestown.org/embodied-intelligence-the-prcs-whole-of-nation-push-into-robotics/
[63] International Federation of Robotics, "Robotics Research: How Asia, Europe and America Invest," *IFR Press Release* (2025), https://ifr.org/news/robotics-research-goverment-programs-asia-europe-and-america-2025/
[64] RAND Corporation, "*Full Stack: China's Evolving Industrial Policy for Artificial Intelligence*," RAND Perspectives (2024), https://www.rand.org/pubs/perspectives/PEA4012-1.html
[65] Jamestown Foundation, "*New Gains in PRC Robotics Software and Hardware*," *China Brief* (2024), https://jamestown.org/new-gains-in-prc-robotics-software-hardware/
[66] Ibid.
[67] International Federation of Robotics, "Robotics Research: How Asia, Europe and America Invest," *IFR Press Release* (2025), https://ifr.org/news/robotics-research-goverment-programs-asia-europe-and-america-2025/
[68] Pavlo Zvenyhorodskyi and Scott Singer, "*Embodied AI: China's Big Bet on Smart Robots*," Carnegie Endowment for International Peace (2025), https://carnegieendowment.org/research/2025/11/embodied-ai-china-smart-robots

underpinning next-generation robotics and physical AI.[69] Humanoid platforms are uniquely demanding systems, requiring the tight integration of perception, manipulation, locomotion, compute, power electronics, and large-scale manufacturing, making them a revealing proxy for broader national capacity in embodied intelligence and advanced production. Rather, China's emphasis on humanoids reflects a strategic effort to use these platforms as integration testbeds for general-purpose robotic intelligence, accelerating learning loops and generating spillover benefits across industrial automation, autonomous systems, and defense-relevant applications.[70, 71] In this context, China's push into humanoid robotics should be understood not as a niche technological bet, but as a deliberate attempt to convert industrial depth, supply-chain control, and data accumulation into long-term economic leverage, military advantage, and geopolitical influence, echoing patterns already evident in sectors such as electric vehicles, batteries, and advanced manufacturing.

[69] Zeyi Yang, "*China's Humanoid-Robot Push Is About Training AI for the Physical World*," *MIT Technology Review*, February 14, 2025, https://www.technologyreview.com/2025/02/14/1111920/chinas-electric-vehicle-giants-pivot-humanoid-robots/

[70] Pavlo Zvenyhorodskyi and Scott Singer, "*Embodied AI: China's Big Bet on Smart Robots*," Carnegie Endowment for International Peace, 2025, https://carnegieendowment.org/research/2025/11/embodied-ai-china-smart-robots

[71] The Diplomat, "From Spectacle to Substance: What China's Humanoid Robot Games Really Mean," *The Diplomat*, August 2025, https://thediplomat.com/2025/08/from-spectacle-to-substance-what-chinas-humanoid-robot-games-really-mean/

Policy Solutions from the Partnership for Robotics Competitiveness

The strategic challenges outlined in earlier sections, ranging from PRC state-directed industrial policy and supply-chain concentration to cybersecurity risk and adoption barriers, require an integrated policy response. The Partnership for Robotics Competitiveness proposes the following policy solutions to operationalize a National Robotics Strategy and translate strategic intent into durable economic and national-security outcomes. These recommendations reflect extensive input from AUVSI's robotics, autonomy, and manufacturing members.

These solutions are designed to work in concert across trade, procurement, industrial policy, workforce development, and allied coordination, ensuring that U.S. robotics leadership is strengthened across the full lifecycle of design, production, deployment, and sustainment.

1. Drive a Coordinated National Approach to Robotics

Sustained leadership requires durable coordination. Congress and the Administration should establish a National Robotics Council to guide federal policy efforts to advance American leadership in advanced robotics. As a first step, the United States needs a plan, thoughtful action by Congress must be undertaken to advance efforts to formulate a National Robotics Strategy to serve as a roadmap.

Additionally, AUVSI urges the creation of a National Robotics Commission, similar in structure to those created for artificial intelligence and biotechnology, comprised of a range of expert stakeholders. This would serve to not only inform a national strategy, but also to serve as a body to advise policymakers, set measurable national goals, coordinate interagency adoption, and support U.S. leadership in international standards-setting and allied engagement, ensuring that strategy translates into sustained competitive advantage.

2. Counter the PRC's Unfair Economic Practices

As described earlier, the PRC's robotics sector is not competing on market terms. It is shaped by massive state subsidies, coordinated industrial planning, preferential financing, and Military-Civil Fusion policies that deliberately blur the line between civilian and military innovation. Left unchecked, these practices risk replicating the market capture and supply-chain dependency observed in the aerial drone sector.

Congress and the Administration should therefore deploy the full range of existing trade and national-security authorities to counter unfair competition in robotics and critical components. This includes the use of antidumping and countervailing duty investigations, Section 301 actions to address forced technology transfer and IP theft, and Section 232 investigations where robotics or enabling components pose a threat to national security. Trade enforcement must be paired with incentives that enable U.S. and allied firms to scale production. These tools are not protectionist; they are corrective measures to restore market integrity and prevent adversary-backed firms from hollowing out U.S. industrial capacity through sustained below-cost pricing.

3. Align Federal Procurement to National Objectives

Federal procurement policy is one of the most effective levers for shaping emerging technology markets. As discussed in prior sections on cybersecurity and system integrity, the presence of PRC-linked robotics platforms and components in government systems poses unacceptable operational and security risks.

Congress should expand and codify prohibitions on the procurement and use of PRC-origin or PRC-linked robotics platforms and components across federal agencies, building on precedents established in recent National Defense Authorization Acts. At the same time, procurement policies should affirmatively prioritize U.S.-made and allied robotics systems that meet defined security, transparency, and supply-chain integrity criteria.

Clear procurement direction would simultaneously reduce security risk, provide long-term demand certainty, and encourage domestic investment, particularly for manufacturers facing high upfront capital costs and long commercialization timelines.

4. Leverage Government Market Power and Advance Market Commitments

Beyond risk-based scoped, and predictable procurement restrictions, the federal government should lead globally in the adoption of robotics to improve mission effectiveness, efficiency, and safety across civilian and defense agencies. As emphasized in earlier sections on adoption barriers, early deployment risk and uncertain demand remain major constraints on scaling robotics technologies.

Advance market commitments and other demand-aggregation mechanisms can help overcome these barriers by providing credible future demand tied to performance, security, and domestic-production benchmarks. For example, advance commitments for robotics in defense applications would not only drive advances in that specific application, but in the scaling of all the technologies and components which comprise it. This would have a knock-on effect which could catalyze early markets and drive wider adoption. These mechanisms allow the government to de-risk private investment without prescribing specific technological approaches, enabling innovation while accelerating deployment at scale.

5. Safeguard the Robotics Ecosystem Through ICTS and Risk-Based Review

Modern robotics systems are inherently connected cyber-physical platforms. As outlined earlier, traditional IT-only security frameworks are insufficient to address the combined digital and physical risks posed by compromised hardware, software, or communications links.

Robust implementation of the Department of Commerce's ICTS authorities is therefore essential to protecting the robotics ecosystem. These authorities enable the review, and (where necessary) prohibition, of transactions involving information and communications technology or services tied to foreign adversaries. Applied effectively, ICTS review can prevent predatory investment, forced technology transfer, and the introduction of insecure components into U.S. robotics supply chains.

6. Protect American Intellectual Property and Sensitive Technologies

Intellectual property protection is foundational to U.S. leadership in robotics. As detailed earlier, PRC industrial strategy relies heavily on systematic intellectual property theft, coerced technology transfer, and exploitation of open research environments.

Congress should ensure that the BIS and other regulatory and enforcement agencies are adequately resourced to investigate and enforce export controls, licensing requirements, and related authorities. At the same time, unilateral enforcement is insufficient. Effective protection of sensitive robotics technologies requires coordinated multilateral export controls and enforcement with trusted allies to prevent adversary access and limit regulatory arbitrage.

7. Forge Secure and Resilient Allied Supply Chains

Advanced robotics systems depend on complex global supply chains for sensors, semiconductors, batteries, rare earth magnets, and other critical inputs. As discussed earlier, over-concentration of these supply chains, particularly where adversary nations control extraction, processing, or manufacturing, creates systemic vulnerability.

A National Robotics Strategy must therefore prioritize allied supply-chain integration alongside domestic investment. This includes deepening industrial partnerships with trusted allies, facilitating trade in strategic inputs, and ensuring that allied-sourced materials and components are treated as preferred inputs within U.S. industrial and procurement policy.

8. Address Strategic Supply-Chain Chokepoints

The PRC's demonstrated willingness to restrict exports of rare earths and related materials illustrates how supply-chain chokepoints can be weaponized for geopolitical leverage. Similar vulnerabilities exist across multiple inputs critical to robotics manufacturing.

To mitigate these risks, Congress and the Administration should pursue a combination of strategic stockpiling, domestic production incentives, and allied sourcing strategies. Existing authorities, including the Defense Production Act and federal manufacturing incentive programs, should be fully leveraged to expand capacity for critical robotics inputs and reduce exposure to adversary coercion.

9. Embrace Industry-Led Standards and Trusted Certification

As robotics systems become more autonomous, networked, and embedded across critical infrastructure, trust, interoperability, and security must be foundational. Adaptive, industry-led standards offer a scalable means of achieving these goals without stifling innovation.

Voluntary certification frameworks, such as AUVSI's Trusted Programs, provide a practical mechanism to establish baseline expectations for cybersecurity, supply-chain transparency, and system integrity. Federal recognition and adoption of such standards can reinforce security outcomes across public and private deployments while preserving flexibility for innovation.

10. Build the American Robotics Industrial Base

Robotics manufacturing is capital-intensive, highly customized, and characterized by long development cycles. As noted earlier, these characteristics create structural barriers to entry and scale for U.S. firms absent targeted policy support.

Congress should therefore extend proven industrial-policy tools, such as production and investment tax credits, to robotics manufacturing. These incentives would lower the cost of scaling domestic production, attract private capital, and strengthen the broader industrial ecosystem that supports robotics innovation.

11. Accelerate Adoption Through Grants and Deployment Support

High upfront deployment costs remain a primary barrier to robotics adoption, particularly for small and medium-sized enterprises. Strategic grant programs can help de-risk early adoption and unlock substantial productivity and labor-efficiency gains while ensuring the benefit of this transformational technology is accessible to all enterprises.

Accelerating adoption not only delivers immediate economic benefits but also generates operational data, workforce familiarity, and ecosystem maturity needed to sustain long-term leadership in robotics and physical AI.

12. Prepare the Workforce for the Robotics Age

Workforce readiness is central to every element of a National Robotics Strategy. As robotics adoption expands, demand will grow for skilled technicians, operators, engineers, and integrators.

Scaling proven workforce programs to ensure workers have the skills can help ensure that workers are equipped with relevant, industry-validated skills. Workforce development tax credits and trusted certification frameworks can further reduce training costs, accelerate hiring, and support high-quality job creation.

13. Drive Innovation Through Pilots and Public-Private Partnerships

Pilot programs and public-private partnerships play a critical role in advancing robotics deployment in transportation, infrastructure, energy, mining, and other priority sectors. These initiatives reduce deployment risk, enable regulatory learning, and generate real-world data needed to refine next-generation robotic and physical-AI systems.

Such efforts also strengthen domestic supply chains by creating early markets for U.S.-developed technologies.

Conclusion and Call to Action

Robotics and physical artificial intelligence will define the future of industrial competitiveness, national security, and economic resilience. The United States retains deep strengths in innovation, engineering talent, and entrepreneurial capacity, but the window to act is narrowing.

Congress and the Administration should act now to ensure U.S. leadership in robotics by advancing a coordinated national strategy, strengthening the industrial base, and supporting responsible deployment.

By applying the lessons of the drone sector, adopting a coordinated National Robotics Strategy, and implementing targeted, risk-based policy solutions, Congress and the Administration can ensure that the United States remains a global leader in robotics. Doing so will strengthen the industrial base, support American workers, safeguard national security, and uphold democratic values.

AUVSI and its members stand ready to work with Congress, federal agencies, state leaders, and allied governments to translate these recommendations into actions.

Further information can be found at AUVSI.ORG/PFRC

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