Innovation Power

Why Technology Will Define the Future of Geopolitics

ERIC SCHMIDT

When Russian forces marched on Kyiv in February 2022, few thought Ukraine could survive. Russia had more than twice as many soldiers as Ukraine. Its military budget was more than ten times as large. The U.S. intelligence community estimated that Kyiv would fall within one to two weeks at most.

Outgunned and outmanned, Ukraine turned to one area in which it held an advantage over the enemy: technology. Shortly after the invasion, the Ukrainian government uploaded all its critical data to the cloud, so that it could safeguard information and keep functioning even if Russian missiles turned its ministerial offices into rubble. The country's Ministry of Digital Transformation, which Ukrainian President Volodymyr Zelensky had established just two years earlier,

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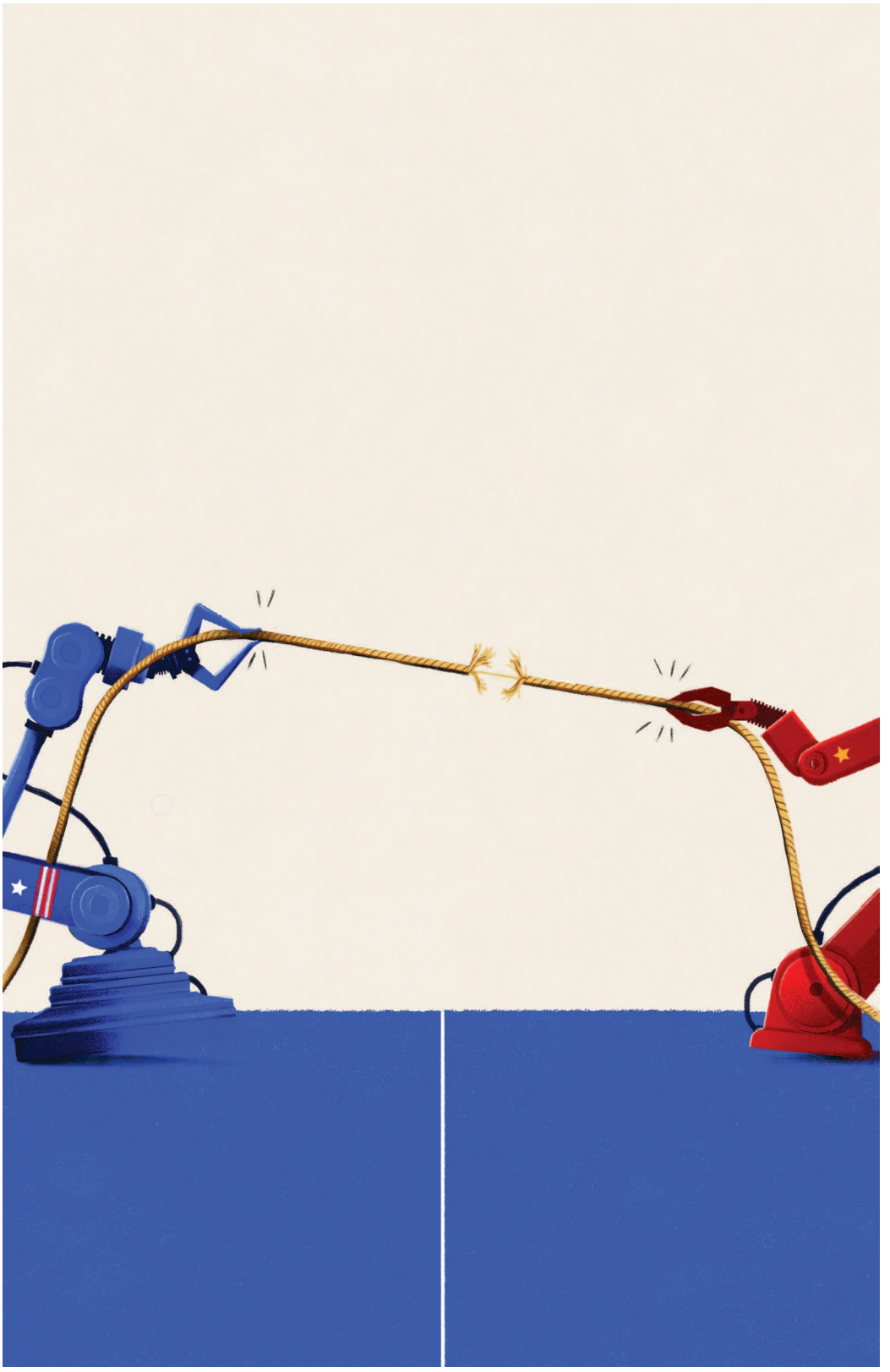

Illustration by Daniel Liévano

repurposed its e-government mobile app, Diia, for open-source intelligence collection, so that citizens could upload photos and videos of enemy military units. With their communications infrastructure in jeopardy, the Ukrainians turned to Starlink satellites and ground stations provided by SpaceX to stay connected. When Russia sent Iranian-made drones across the border, Ukraine acquired its own drones specially designed to intercept their attacks—while its military learned how to use unfamiliar weapons supplied by Western allies. In the cat-and-mouse game of innovation, Ukraine simply proved nimbler. And so what Russia had imagined would be a quick and easy invasion has turned out to be anything but.

Increasingly, AI systems will start making decisions themselves.

Ukraine's success can be credited in part to the resolve of the Ukrainian people, the weakness of the Russian military, and the strength of Western support. But it also owes to the defining new force of international politics: innovation power. Innovation power is the ability to invent, adopt, and adapt new technologies. It contributes to both hard and soft power. High-tech weapons systems increase military might, new platforms and the standards that govern them provide economic leverage, and cutting-edge research and technologies enhance global appeal. There is a long tradition of states harnessing innovation to project power abroad, but what has changed is the self-perpetuating nature of scientific advances. Developments in artificial intelligence in particular not only unlock new areas of scientific discovery; they also speed up that very process. Artificial intelligence supercharges the ability of scientists and engineers to discover ever more powerful technologies, fostering advances in artificial intelligence itself as well as in other fields—and reshaping the world in the process.

The ability to innovate faster and better—the foundation on which military, economic, and cultural power now rest—will determine the outcome of the great-power competition between the United States and China. For now, the United States remains in the lead. But China is catching up in many areas and has already surged ahead in others. To emerge victorious from this century-defining contest, business as usual will not do. Instead, the U.S. government will have to overcome its stultified bureaucratic impulses, create favorable conditions for innovation, and invest in the tools and talent needed to kick-start the virtuous cycle of technological advancement. It needs to commit itself

to promoting innovation in the service of the country and in the service of democracy. At stake is nothing less than the future of free societies, open markets, democratic government, and the broader world order.

KNOWLEDGE IS POWER

The nexus between technological innovation and global domination dates back centuries, from the muskets the conquistador Francisco Pizarro wielded to defeat the Inca Empire to the steamboats Commodore Matthew Perry commanded to force the opening of Japan. But the sheer speed at which innovation is happening has no precedent. Nowhere is this change clearer than in one of the foundational technologies of our time: artificial intelligence.

Today's AI systems can already provide key advantages in the military domain, where they are able to parse millions of inputs, identify patterns, and alert commanders to enemy activity. The Ukrainian military, for example, has used AI to efficiently scan intelligence, surveillance, and reconnaissance data from a variety of sources. Increasingly, however, AI systems will move beyond merely assisting human decision-making and start making decisions themselves. John Boyd, a military strategist and U.S. Air Force colonel, coined the term "OODA loop"—observe, orient, decide, act—to describe the decision-making process in combat. Crucially, AI will be able to execute each part of the OODA loop much faster. Conflict can happen at the speed of computers, not the speed of people. As a result, command-and-control systems that rely on human decision-makers—or, worse, complex military hierarchies—will lose out to faster, more efficient systems that team machines with humans.

In previous eras, the technologies that shaped geopolitics—from bronze to steel, steam power to nuclear fission—were largely singular. There was a clear threshold of technological mastery, and once a country reached it, the playing field was leveled. Artificial intelligence, by contrast, is generative in nature. By presenting a platform for continuous scientific and technological innovation, it can lead to yet more innovation. That phenomenon makes the AI age fundamentally different from the Bronze Age or the steel age. Rather than natural resource wealth or mastery of a given technology, the source of a country's power now lies in its ability to continuously innovate.

This virtuous cycle will only get faster and faster. Once quantum computing comes of age, superfast computers will allow for the

Liftoff: testing a prototype of a homemade weaponized drone, Kyiv, Ukraine, November 2022

processing of ever-larger amounts of data, producing ever-smarter AI systems. These AI systems, in turn, will be able to produce breakthrough innovations in other emerging fields, from synthetic biology to semiconductor manufacturing. Artificial intelligence will change the very nature of scientific research. Instead of making progress one study at a time, scientists will discover the answers to age-old questions by analyzing massive data sets, freeing the world's smartest minds to devote more time to developing new ideas. As a foundational technology, AI will be critical in the race for innovation power, lying behind countless future developments in drug discovery, gene therapy, material science, and clean energy—and in AI itself. Faster airplanes did not help build faster airplanes, but faster computers will help build faster computers.

Even more powerful than today's artificial intelligence is a more comprehensive technology—for now, given current computing power, still hypothetical—called "artificial general intelligence," or AGI. Whereas traditional AI is designed to solve a discrete problem, AGI should be able to perform any mental task a human can and more. Imagine an AI system that could answer seemingly intractable questions, such as the best way to teach a million children English or to treat a case of Alzheimer's disease. The advent of AGI remains years, perhaps even

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decades, away, but whichever country develops the technology first will have a massive advantage, since it could then use AGI to develop ever more advanced versions of AGI, gaining an edge in all other domains of science and technology in the process. A breakthrough in this field could usher in an era of predominance not unlike the short period of nuclear superiority the United States enjoyed in the late 1940s.

Whereas many of AI's most transformative effects are still far off, innovation in drones is already upending the battlefield. In 2020, Azerbaijan employed Turkish- and Israeli-made drones to gain a decisive advantage in its war against Armenia in the disputed Nagorno-Karabakh region, racking up battlefield victories after more than two decades of military stalemate. Similarly, Ukraine's fleet of drones—many of which are low-cost commercial models repurposed for reconnaissance behind enemy lines—have played a critical role in its successes.

Drones offer distinct advantages over traditional weapons: they are smaller and cheaper, offer unmatched surveillance capabilities, and reduce soldiers' risk exposure. Marines in urban warfare, for example, could be accompanied by microdrones that serve as their eyes and ears. Over time, countries will improve the hardware and software powering drones to outinnovate their rivals. Eventually, autonomous weaponized drones—not just unmanned aerial vehicles but also ground-based ones—will replace soldiers and manned artillery altogether. Imagine an autonomous submarine that could quickly move supplies into contested waters or an autonomous truck that could find the optimal route to carry small missile launchers across rough terrain. Swarms of drones, networked and coordinated by AI, could overwhelm tank and infantry formations in the field. In the Black Sea, Ukraine has used drones to attack Russian ships and supply vessels, helping a country with a minuscule navy constrain Russia's mighty Black Sea Fleet. Ukraine offers a preview of future conflicts: wars that will be waged and won by humans and machines working together.

As developments in drones make clear, innovation power underlies military power. First and foremost, technological dominance in crucial domains bolsters a country's ability to wage war and thus strengthens its deterrent capabilities. But innovation also shapes economic power by giving states leverage over supply chains and the ability to make the rules for others. Countries reliant on natural resources or trade, especially those that must import rare or foundational goods, face vulnerabilities others do not.

Consider the power China can wield over the countries it supplies with communications hardware. It is no surprise that countries dependent on Chinese-supplied infrastructure—such as many countries in Africa, where components produced by Huawei make up about 70 percent of 4G networks—have been loath to criticize Chinese human rights violations. Taiwan's primacy in semiconductor manufacturing, likewise, provides a powerful deterrent against invasion, since China has little interest in destroying its largest source of microchips. Leverage also accrues to countries pioneering new technologies. The United States, thanks to its role in the foundation of the Internet, has for decades enjoyed a seat at the table defining Internet regulations. During the Arab Spring, for example, the fact that the United States was home to technology companies that provided the backbone of the Internet enabled those companies to refuse Arab governments' censorship requests.

Less obvious but also crucial, technological innovation buoys a country's soft power. Hollywood and tech companies such as Netflix and YouTube have built up a trove of content for an increasingly global consumer base—all the while, helping spread American values. Such streaming services project the American way of life into living rooms around the world. Similarly, the prestige associated with U.S. universities and the opportunities for wealth creation created by U.S. companies attract strivers from across the globe. In short, a country's ability to project power in the international sphere—militarily, economically, and culturally—depends on its ability to innovate faster and better than its competitors.

RACE TO THE TOP

The main reason innovation now lends such a massive advantage is that it begets more innovation. In part, it does so because of the path dependency that arises from clusters of scientists attracting, teaching, and training other great scientists at research universities and large technology companies. But it also does so because innovation builds on itself. Innovation relies on a loop of invention, adoption, and adaptation—a feedback cycle that fuels yet more innovation. If any link in the chain breaks, so, too, does a country's ability to innovate effectively.

A lead in invention is typically built on years of prior research. Consider the way the United States led the world into the 4G era of telecommunications. The rollout of 4G networks across the country

facilitated the early development of mobile applications such as Uber that required faster cellular data connections. With that lead, Uber was able to refine its product in the United States so it could roll it out in developing countries. This led to many more customers—and much more feedback to incorporate—as the company adapted its product for new markets and new releases.

But the moat around countries that enjoy structural advantages in technology is shrinking. Thanks in part to more accessible academic research and the rise of open-source software, technologies now diffuse more quickly around the world. The availability of new advances has helped competitors catch up at record speed, as China eventually did in 4G. Although some of China's recent technological success stems from economic espionage and a disregard for patents, much of it traces back to innovative, rather than derivative, efforts to adapt and implement new technology.

Innovation begets more innovation.

Indeed, Chinese companies have enjoyed resounding success in adopting and commercializing foreign technological breakthroughs. In 2015, the Chinese Communist Party laid out its "Made in China 2025" strategy to achieve self-sufficiency in high-tech industries such as telecommunications and AI. As part of this bid, it announced an economic plan of "dual circulation," whereby China intends to boost both domestic and foreign demand for its goods. Through public-private partnerships, direct subsidies to private companies, and support for state-backed companies, Beijing has poured billions of dollars into ensuring it comes out ahead in the race for technological supremacy. So far, the record is mixed. China is ahead of the United States in some technologies yet lags in others.

It is hard to say whether China will seize the lead in AI, but top officials in Beijing certainly think it will. In 2017, Beijing announced plans to become the global leader in artificial intelligence by 2030, and it may achieve that goal even earlier than expected. China has already accomplished its goal of becoming the world's leader in AI-based surveillance technology, which it not only uses to control dissidents at home but also sells to authoritarian governments abroad. China still ranks behind the United States in attracting the best minds in AI, with almost 60 percent of top-tier researchers working in U.S. universities. But China's loose privacy laws, mandatory data collection,

and targeted government funding give the country a key advantage. Indeed, it already leads in the production of autonomous vehicles.

For now, the United States still retains an edge in quantum computing. Yet over the past decade, China has invested at least $10 billion in quantum technology, roughly ten times as much as the U.S. government. China is working to build quantum computers so powerful that they will easily crack today's encryption. The country is also investing heavily in quantum networks—a way of transmitting information in the form of quantum bits—presumably in the hope that such networks would be impervious to monitoring by other intelligence agencies. Even more alarming, the Chinese government may already be storing stolen and intercepted communications with an eye to decrypting them once it possesses the computing power to do so, a strategy known as "store now, decrypt later." When quantum computers become fast enough, all communications encrypted through non-quantum methods will be at risk for interception, raising the stakes of achieving this breakthrough first.

More than half of all AI researchers in the United States hail from abroad.

China is also actively trying to catch up with the United States in synthetic biology. Scientists in this field are working on a range of new biological developments, including microbe-made cement that absorbs carbon dioxide, crops with an increased ability to sequester carbon, and plant-based meat substitutes. Such technology holds enormous promise to fight climate change and create jobs, but since 2019, Chinese private investment in synthetic biology has outpaced U.S. investment.

When it comes to semiconductors, China has ambitious plans, too. The Chinese government is funding unprecedented efforts to become a leader in semiconductor manufacturing by 2030. Chinese companies are currently creating what are known in the industry as "seven nanometer" chips, but Beijing has set its sights further, announcing plans to domestically produce the new generation of "five nanometer" chips. For now, the United States continues to outperform China in semiconductor design, as do U.S.-aligned Taiwan and South Korea. In October 2022, the Biden administration took the important step of blocking leading U.S. companies producing AI computer chips from selling to China as part of a package of restrictions released by the Department of Commerce. Yet Chinese companies control

85 percent of the processing of the rare-earth minerals that go into these chips and other critical electronics, offering an important point of leverage over their competitors.

A BATTLE OF SYSTEMS

The competition between the United States and China is as much a competition between systems as it is between states. In the Chinese model of civil-military fusion, the government promotes domestic competition and funds emerging winners as "national champions." These companies play a dual role, maximizing commercial success and advancing Chinese national security interests. The American model, on the other hand, relies on a more disparate set of private actors. The federal government provides funding to basic science but largely leaves innovation and commercialization to the market.

For a long time, the trifecta of government, industry, and academia was the primary source of American innovation. This collaboration drove many technological breakthroughs, from the moon landing to the Internet. But with the end of the Cold War, the U.S. government grew averse to allocating funding for applied research, and it even lowered the amount devoted to fundamental research. Although private spending has taken off, public investments have plateaued over the past half century. In 2015, the share of government funding for basic research dropped below 50 percent for the first time since the end of World War II, having hovered around 70 percent in the 1960s. Meanwhile, the geometry of innovation—the respective role of public and private players in driving technological progress—has changed since the Cold War, in ways that have not always yielded what the country needs. The rise of venture capital helped accelerate adoption and commercialization, but it did little to address higher-order scientific problems.

The reasons for Washington's reluctance to fund the science that serves as the foundation of innovation power are structural. Innovation requires risk and, at times, failure—something politicians are loath to accept. Innovation can demand long-term investments, but the U.S. government operates on a single-year budget cycle and, at most, a two-year political cycle. Despite these obstacles, Silicon Valley (along with other hot spots in the United States) has still managed to encourage innovation. The American success story relies on a potent mix of inspiring ambition, startup-friendly legal and tax regimes, and a culture of openness that allows entrepreneurs and researchers to iterate and improve on new ideas.

That may not be enough, however. Government support has long played a critical role in jump-starting innovation in the United States, and research in technologies that seem outlandish now may prove critical in the not-too-distant future. In 2013, for example, the Defense Advanced Research Projects Agency invested in messenger RNA vaccines, working with the biotech company Moderna, which would later develop and deliver a COVID-19 vaccine in record time. But such examples are rarer than they should be.

Competition with China demands a reenergizing of the interplay among the government, the private sector, and academia. Just as the Cold War led to the creation of the National Security Council, today's tech-fueled competition should spur a rethinking of existing policymaking structures. As the National Security Commission on Artificial Intelligence (which I chaired) recommended, a new "technology competitiveness council," inspired by the NSC, could help coordinate action among private actors and develop a national plan to advance crucial emerging technologies. In a promising sign, Congress appears to have recognized the need for decisive support. In 2022, in a bipartisan vote, it passed the CHIPS and Science Act, which directs $200 billion in funding for scientific R & D over the next ten years.

INVESTING IN THE FUTURE

As part of its effort to ensure that it remains an innovation superpower, the United States will need to invest billions of dollars in key areas of technological competition. In semiconductors, perhaps the most vital technology today, the U.S. government should redouble its efforts to onshore and "friend shore" supply chains, relocating them to the United States or friendly countries. In renewable energy, it should fund R & D for microelectronics, stockpile the rare-earth minerals (such as lithium and cobalt) needed for batteries and electric vehicles, and invest in new technologies that can replace lithium-ion batteries and offset China's resource dominance. Meanwhile, the rollout of 5G in the United States has been slow, in part because government agencies—most notably, the Department of Defense—control most of the high-frequency radio spectrum that 5G uses. To catch up with China, the Pentagon should open up more of the spectrum to private actors.

The United States will need to invest in all parts of the innovation cycle, funding not just basic research but also commercialization. Meaningful innovation requires both invention and implementation, the abil-

ity to execute and commercialize new inventions at scale. This is often the main stumbling block. Research in electric cars, for example, helped General Motors bring its first model onto the market in 1996, but it took two more decades before Tesla mass-produced a commercially viable model. Every new technology, from AI to quantum computing to synthetic biology, must be pursued with the clear goal of commercialization.

In addition to directly investing in the technologies that fuel innovation power, the United States must invest in the input that lies at the core of innovation: talent. The United States boasts the world's top startups, incumbent companies, and universities, all of which attract the best and the brightest from around the world. Yet too many talented people are prevented from coming to the United States by its outdated immigration system. Instead of creating an easy path to a green card for foreigners who earn STEM degrees from American schools, the current system makes it needlessly difficult for top graduates to contribute to the U.S. economy.

The United States has an asymmetric advantage when it comes to employing highly skilled immigrants, and its enviable living standards and abundant opportunities explain why the country has attracted most of the world's brightest AI minds. More than half of all AI researchers working in the United States hail from abroad, and the demand for AI talent still far exceeds supply. If the United States closes its doors to talented immigrants, it risks losing its innovative edge. Just as the Manhattan Project was led in large part by refugees and émigrés from Europe, the next American technological breakthrough will almost certainly rely on immigrants.

THE BEST DEFENSE

As part of its efforts to translate innovation into hard power, the United States must fundamentally rethink some of its defense policies. During the Cold War, the country designed various "offset" strategies to counterbalance Soviet numerical superiority through military strategy and technological innovations. Today, Washington needs what the Special Competitive Studies Project has called an "Offset-X" strategy, a competitive approach through which the United States can maintain technological and military superiority.

Given how much modern militaries and economies rely on digital infrastructure, any future great-power war is likely to start with a cyberstrike. The United States' cyberdefenses, therefore, need a response time faster than humans' reaction time. Having faced constant cyberattacks

Chipping away: on a semiconductor production line, Jiangsu Province, China, September 2022

even in peacetime, the United States should armor itself with redundancy, creating backup systems and alternative paths for data flows.

What starts in cyberspace could easily escalate into the physical realm, and there, too, the United States will need to meet new challenges. To counter possible swarm drone attacks, it must invest in defensive artillery and missile systems. To improve battlefield awareness, the U.S. military should focus on deploying a network of inexpensive sensors powered by AI to monitor contested areas, an approach that is often more effective than a single, exquisitely crafted system. As human intelligence becomes harder to obtain, the United States must increasingly rely on the largest constellation of sensors of any country, ranging from undersea to outer space. It will also need to focus more on open-source intelligence, given that most of the world's data today is publicly available. Without this capability, the United States risks being surprised by its intelligence failures.

When it comes to actual fighting, military units should be networked and decentralized to better outmaneuver opponents. Facing adversaries with rigid military hierarchies, the United States could gain an advantage by using smaller, more connected units whose members are adept at network-based decision-making, employing the tools of artificial intelligence to their advantage. For example, a single unit

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could bring together capabilities in intelligence collection, long-range missile attacks, and electronic warfare. The Pentagon needs to provide battlefield commanders with all the best information and allow them to make the best choices on the ground.

The U.S. military must also learn to integrate new technologies into its procurement process, battle plans, and warfighting. In the four years that I chaired the Defense Innovation Board, I was astounded by how difficult this was to do. A major bottleneck is the Pentagon's burdensome procurement process: major weapons systems take more than ten years to design, develop, and deploy. The Department of Defense should look for inspiration in the way the tech industry designs products. It should build missiles the way companies now build electric cars, using a design studio to develop and simulate software, looking for innovations ten times as fast and as cost-effective as current processes. The current procurement system is especially ill suited for a future in which software primacy proves decisive on the battlefield.

The United States spends four times as much as any other country to procure military systems, but price is a poor metric for judging innovation power. In April 2022, Ukrainian forces fired two Neptune missiles at the *Moskva*, a 600-foot Russian warship, sinking the vessel. The ship cost $750 million; the missiles, $500,000 apiece. Likewise, China's state-of-the-art hypersonic antiship missile, the YJ-21, could someday sink a $10 billion U.S. aircraft carrier. The U.S. government should think twice before committing another $10 billion and ten years to such a vessel. It often makes more sense to buy many low-cost items instead of investing in a few high-ticket prestige projects.

PLAYING TO WIN

In the contest of the century—the U.S. rivalry with China—the deciding factor will be innovation power. Technological advances in the next five to ten years will determine which country gains the upper hand in this world-shaping competition. The challenge for the United States, however, is that government officials are incentivized to avoid risk and focus on the short term, leaving the country to chronically underinvest in the technologies of the future.

If necessity is the mother of invention, war is the midwife of innovation. Speaking to Ukrainians on a visit to Kyiv in the fall of 2022, I heard from many that the first months of the war were the most productive of their lives. The United States' last truly global

war—World War II—led to the widespread adoption of penicillin, a revolution in nuclear technology, and a breakthrough in computer science. Now, the United States must innovate in peacetime, faster than ever before. By failing to do so, it is eroding its ability to deter—and, if necessary, to fight and win—the next war.

The alternative could be disastrous. Hypersonic missiles could leave the United States defenseless, and cyberattacks could cripple the country's electric grid. Perhaps even more important, the warfare of the future will target individuals in completely new ways: authoritarian states such as China and Russia may be able to collect individual data on Americans' shopping habits, location, and even DNA profiles, allowing for tailor-made disinformation campaigns and even targeted biological attacks and assassinations. To avert these horrors, the United States needs to make sure it remains ahead of its technological competitors.

The principles that have defined life in the United States—freedom, capitalism, individual effort—were the right ones for the past and remain so for the future. These basic values lie at the foundation of an innovation ecosystem that is still the envy of the world. They have enabled breakthroughs that have transformed everyday life around the world. The United States started the innovation race in pole position, but it cannot rest assured it will remain there. Silicon Valley's old mantra holds true not just in industry but also in geopolitics: innovate or die.