

AVOIDING GREAT POWER WAR PROJECT

Is China Beating the U.S. to AI Supremacy?

Graham Allison

Eric Schmidt



HARVARD Kennedy School

BELFER CENTER

for Science and International Affairs

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A Watrix employee works at his desk in their company's offices in Beijing, October 31, 2018. Watrix, a Chinese technology startup hopes to begin selling software that recognizes people by their body shape and how they walk, enabling identification when faces are hidden from cameras.

AP Photo / Mark Schiefelbein

The US-China Race for Artificial Intelligence

Combining decades of experience advancing frontier technologies, on the one hand, and analyzing national security decisionmaking, on the other, we have been collaborating over the past year in an effort to understand the national security implications of China's great leap forward in artificial intelligence (AI). Our purpose in this essay is to sound an alarm over China's rapid progress and the current prospect of it overtaking the United States in applying AI in the decade ahead; to explain why AI is for the autocracy led by the Chinese Communist Party (hereafter, the "Party") an existential priority; to identify key unanswered questions about the dangers of an unconstrained AI arms race between the two digital superpowers; and to point to the reasons why we believe that this is a race the United States can and must win.

We begin with four key points. First, most Americans believe that U.S. leadership in advanced technologies is so entrenched that it is unassailable. Likewise, many in the American national security community insist that in the AI arena China can never be more than a "near-peer competitor." Both are wrong. In fact, China stands *today* as a *full-spectrum peer competitor* of the United States in commercial and national security applications of AI. Beijing is not just trying to master AI—it is succeeding. Because AI will have as transformative an impact on commerce and national security over the next two decades as semiconductors, computers and the web have had over the past quarter century, this should be recognized as a matter of grave national concern.^{1, 2, 3}

- 1 As Google CEO Sundar Pichai has said, "AI is one of the most profound things we're working on as humanity. It's more profound than fire or electricity." Amy Thomson and Stephanie Bodoni, "Google CEO Thinks AI Will Be More Profound Change Than Fire," *Bloomberg*, January 22, 2020. <https://www.bloomberg.com/news/articles/2020-01-22/google-ceo-thinks-ai-is-more-profound-than-fire>
- 2 Jason Matheny, director of Georgetown's Center for Security and Emerging Technology, has said, "There are specific application areas that are relevant to national security, such as cybersecurity, intelligence and systems for analysis and collection, as well as AI that is embedded in weapon systems of competing nations, that we have to be aware of, and able to develop countermeasures to." Q&A With Jason Matheny, Founding Director of the Center for Security and Emerging Technology, Georgetown University, February 28, 2019 <https://www.georgetown.edu/news/qa-with-jason-matheny-founding-director-of-the-center-for-security-and-emerging-technology/>
- 3 As the November 2019 report of the NSC AI stated, "The Commission's attempts to predict AI's impact on national security is like Americans in the late 19th century pondering the impact of electricity on war and society." "Interim Report," National Security Commission on Artificial Intelligence, November 2019. <https://www.epic.org/foia/epic-v-ai-commission/AI-Commission-Interim-Report-Nov-2019.pdf>

Second, China's zeal to master AI goes far beyond its recognition that this suite of technologies promises to be the biggest driver of economic advances in the next quarter century. For the Party, AI is mission critical. The command of 1.4 billion citizens by a Party-controlled authoritarian government is a herculean challenge. Since the fall of the Soviet Union, Americans have been confident that authoritarian governments are doomed to fail—eventually. But AI offers a realistic possibility of upending this proposition. AI could give the Party not just an escape hatch from the “end of history,”⁴ but a claim to advance a model of governance—a national operating system—superior to today's dysfunctional democracies. As one former Democratic presidential candidate put it: “China is using technology to perfect dictatorship.”⁵ It's a value proposition that resonates with many leaders around the world. As former Google CEO Eric Schmidt has argued: “if the Soviet Union had been able to leverage the kind of sophisticated data observation, collection and analytics employed by the leaders of Amazon today, it might well have won the Cold War.”

Third, while we share the general enthusiasm about AI's potential to make huge improvements in human wellbeing, the development of machines with intelligence vastly superior to humans will pose special, perhaps even unique risks. In 1946, Albert Einstein warned, “the unleashed power of the atom has changed everything save our modes of thinking, and thus we drift towards unparalleled catastrophe.” We believe the same could be said of AI. Henry Kissinger has identified these risks in what we call “Kissinger's Specter.” In his words, AI threatens an unpredictable revolution in our consciousness and our thinking, and an “inevitable evolution in our understanding of truth and reality.”⁶ In response to Einstein's insight,

4 Francis Fukuyama's *The End of History and the Last Man* argues that in the unipolar moment after the collapse of the Soviet Union, humanity had reached “the end of history...the end-point of mankind's ideological evolution and the universalization of Western liberal democracy as the final form of human government.” Francis Fukuyama, *The End of History and the Last Man* (New York: Free Press, 1992) 3-18.

5 In the first Democratic primary debate on June 27, 2019, Peter Buttigieg said, “We have to recognize that the China challenge is a serious one. This is not something to dismiss or waive away. China is using technology for the perfection of dictatorship...Meanwhile, China is investing so they could soon be able to run circles around us in artificial intelligence and this president is fixated on the relationship as if all that mattered was the balance on dishwashers. We have a moment when their authoritarian model is an alternative to ours because ours looks so chaotic because of internal divisions. The biggest thing we have to do is invest in our own domestic competitiveness.” Ursula Perano, “Debate night: What the candidates are saying on China,” *Axios*, June 28, 2019. <https://www.axios.com/debate-night-what-the-candidates-are-saying-on-china-a530a78a-d7e6-462c-b172-7d17e463d9f3.html>

6 Henry Kissinger in direct conversation with the author. Also see “The Metamorphosis” in *The Atlantic* by Kissinger, Eric Schmidt, and Daniel Huttenlocher. <https://www.theatlantic.com/magazine/archive/2019/08/henry-kissinger-the-metamorphosis-ai/592771/>

the technologists and strategists who had built and used the bomb to end World War II joined forces to find ways to prevent a nuclear World War III. Meeting the challenges posed by AI will require nothing less.

Fourth, China's advantages in size, data collection and national determination have allowed it over the past decade to close the gap with American leaders of this industry. It is currently on a trajectory to overtake the United States in the decade ahead. Nonetheless, if the United States will awake to the challenge and mobilize a national effort, we believe that it can develop and execute a winning strategy.

For many readers, AI is just the latest bright, shiny object on the technology horizon. A brief explainer to provide some further context may be helpful.

AI encompasses big data, machine learning and multiple related technologies that allow machines to act in ways humans describe as “intelligent” when we do the same thing.⁷ For example, consider GPS navigation app Waze locating the best route through heavy traffic; Amazon's eerily relevant product suggestions; or the programmed machines that now regularly defeat world masters in chess. Today's leading information technology companies—including the FAANGS (Facebook, Amazon, Apple, Netflix and Google) and BATS (Baidu, Alibaba and Tencent)—are betting their R&D budgets on the AI revolution. As Amazon's Jeff Bezos said this year, “We're at the beginning of a golden age of AI.”⁸

7 “The State of AI Report 2019” (<https://www.stateof.ai/>), produced by Nathan Benaich and Ian Hogarth, offers an overview of the progress of AI and its implications.

8 James Vincent, “Jeff Bezos is launching a new conference dedicated to AI, optimism, and Amazon,” *The Verge*, January 17, 2019. <https://www.theverge.com/2019/1/17/18186481/amazon-remarks-jeff-bezos-conference-ai-machine-learning-robotics-space>

China's AI Surge

Though still in their infancy, AI technologies will be drivers of future economic growth and national security. From facial recognition and fintech to drones and 5G, China is not just catching up. In many cases, it has already overtaken the United States to become the world's undisputed No. 1. In some arenas, because of constitutional constraints and different values, the United States willfully forfeits the race. In others, China is simply more determined to win.

China's AI surge is so recent that anyone not watching closely has likely missed it. As late as 2015, when assessing its international competition, American industry leaders—Google, Microsoft, Facebook and Amazon—saw Chinese companies in their rearview mirrors alongside German or French firms in the third tier. But this changed four years ago—in 2016—when leading AI application company DeepMind fielded a machine that defeated world champion Lee Sedol in the world's most complex board game, Go.⁹ Even after several American companies' machines had bested the chess masters of the universe¹⁰, most Chinese remained confident that machines could never beat Go champions, since Go is ten thousand times more complex than chess. Thus, DeepMind's decisive victory became for China a “Sputnik moment”¹¹—a jolt as dramatic as the Soviet Union's launch of the first satellite into space that sparked America's whole-of-nation surge in math and science, NASA's creation and the original “moon shot.”

Kai-Fu Lee's book *AI Superpowers* offers an insightful summary of China's engagement in the field. It began with President Xi Jinping's personal reaction to the defeat of the world's Go champion. Declaring that this was a technology in which China had to lead, he set specific targets for 2020 and 2025 that put China on a path to dominance over AI technology and

9 In March 2016, AlphaGo, an AI system designed by DeepMind, beat Lee Sedol, one of the world's best Go players in a best-of-five series, winning four out of five games. Cadie Metz, “Google's AI Wins Fifth and Final Game Against Go Genius Lee Sedol,” *Wired*, March 15, 2016. <https://www.wired.com/2016/03/googles-ai-wins-fifth-final-game-go-genius-lee-sedol/>

10 In 1997, IBM's DeepBlue system beat chess champion Gary Kasparov.

11 See Kai-Fu Lee's *AI Superpowers: China, Silicon Valley, and the New World Order*, (Boston: Houghton Mifflin Harcourt, 2018).

related applications by 2030.¹² Recognizing that this would have to be led by entrepreneurial companies rather than agencies of government, he designated five companies to become China's national champions: Baidu, Alibaba, Tencent, iFlytek and SenseTime.¹³ Twelve months after Xi's directive, investments in Chinese AI startups had topped investments in American AI startups.¹⁴ By 2018, China filed 2.5 times more patents in AI technologies than the United States.¹⁵ And this year China is graduating three times as many computer scientists as the United States.

In contrast to nuclear weapons—where governments led in discovery, development and deployment—AI and related technologies have been created and are being advanced by private firms and university researchers. The military establishments in Washington and Beijing are essentially playing catch-up, adopting and adapting private-sector products.

Where do these two competitors stand in the AI race today? Consider leading indicators under six key headings: product market tests, financial market tests, research publications and patents, results in international competitions, talent and national operating environments.

Consumers' choices of products in markets speak for themselves. In fintech, China stands alone. Tencent's WeChat Pay has nine hundred million Chinese users,¹⁶ while Apple Pay only has 22 million in the United States.¹⁷

12 By 2020, China's AI industry will be "in line" with that of most advanced countries; by 2025, China aims to reach a "world-leading" level in some AI fields; and by 2030, China seeks to become the world's "primary" AI innovation center. See "China's Current Capabilities, Policies, and Industrial Ecosystem in AI," Testimony by Jeffrey Ding before the US-China Economic and Security Review Commission. https://www.uscc.gov/sites/default/files/June%207%20Hearing_Panel%201_Jeffrey%20Ding_China%27s%20Current%20Capabilities%2C%20Policies%2C%20and%20Industrial%20Ecosystem%20in%20AI.pdf

13 See Greg Allen's 2019 "Understanding China's AI Strategy" report from the Center for a New American Security (CNAS). Allen writes that this position "gave the companies privileged positions for national technical standards setting and also was intended to give the companies confidence." <https://www.cnas.org/publications/reports/understanding-chinas-ai-strategy>

14 James Vincent, "China overtakes US in AI startup funding with a focus on facial recognition and chips," *The Verge*, February 22. <https://www.theverge.com/2018/2/22/17039696/china-us-ai-funding-startup-comparison>

15 Yuki Okoshi, "China overtakes US in AI patent rankings," *Nikkei Asian Review*, March 10, 2019. <https://asia.nikkei.com/Business/Business-trends/China-overtakes-US-in-AI-patent-rankings>

16 Harrison Jacobs, "One photo shows that China is already in a cashless future," *Business Insider*, May 29, 2018. <https://www.businessinsider.com/alipay-wechat-pay-china-mobile-payments-street-vendors-musicians-2018-5>

17 Kate Rooney, "Mobile payments have barely caught on in the US, despite the rise of smartphone," *CNBC*, August 29, 2019. <https://www.cnb.com/2019/08/29/why-mobile-payments-have-barely-caught-on-in-the-us.html>

And when it comes to capability, WeChat Pay can do much more than Apple Pay. Chinese consumers use their app to buy coffee at Starbucks and new products from Alibaba, pay bills, transfer money, take out loans, make investments, donate to charity and manage their bank accounts. In doing so, they generate a treasure trove of granular data about individual consumer behavior that AI systems use to make better assessments of individuals' credit-worthiness, interest in products, capacity to pay for them and other behavior. In mobile payments, Chinese spend \$50 for every dollar Americans spend, in total, \$19 trillion in 2018.¹⁸ U.S. mobile payments have yet to reach \$1 trillion. Credit cards are as old-fashioned to Chinese millennials as handwritten checks are to their American counterparts. Mark Zuckerberg has noticed: Facebook's major moves last year into digital payments,¹⁹ including the recent introduction of Facebook Pay, are copying Tencent, rather than the other way around.

In facial recognition, the world's most valuable AI startup is Chinese company SenseTime²⁰—a company whose headquarters Graham visited in October. (While there, Graham also took a tour of Zhongguancun—China's version of Silicon Valley—guided by Kai-Fu Lee whose hedge fund is one of the leading VC investors in Chinese AI startups.) In 2018's international competition for facial recognition, Chinese teams claimed the top five places.²¹ Chinese firms—such as Hikvision and Dahua Technology, which control a third of the world's security camera market²²; Tiandy, whose cameras need light from only a single star at night to capture high-definition color images²³; and Wuhan Guide Infrared, which specializes in infrared

18 See Peter Diamandis, "China is Quickly Becoming an AI Superpower." <https://singularityhub.com/2018/08/29/china-ai-superpower/>

19 See Facebook Pay. <https://pay.facebook.com/>

20 In a few years, SenseTime became the world's most valuable AI company, with a 2019 valuation of \$4.5bn. Bernard Marr, "Meet The World's Most Valuable AI Startup: China's SenseTime," *Forbes*, June 17, 2019. <https://www.forbes.com/sites/bernardmarr/2019/06/17/meet-the-worlds-most-valuable-ai-startup-chinas-sensetime/#6d3bb9d5309f>

21 In the 2018 Face Recognition Vendor Test (FRVT), hosted by the National Institute of Standards and Technology (NIST) under the US Department of Commerce, Shanghai-based AI startup YITU Technology took the top two places, followed by two algorithms from SenseTime, followed by one from the Shenzhen Institutes of Advantaged Technology of the Chinese Academy of Sciences. "Chinese AI teams win big in global facial recognition competition," *Xinhua*, November 21, 2018. http://www.xinhuanet.com/english/2018-11/21/c_137622674.htm

22 In 2019, Hikvision and Dahua controlled 40% of the worldwide market. "US sanctions blue Chinese dominance in security cameras," *Nikkei Asian Review*, November 12, 2019. <https://asia.nikkei.com/Economy/Trade-war/US-sanctions-blur-Chinese-dominance-in-security-cameras>

23 Blake Schmidt and Venus Feng, "The Companies Behind China's High-Tech Surveillance State," *Bloomberg*, February 21, 2019. <https://www.bloomberg.com/news/articles/2019-02-21/the-companies-behind-china-s-high-tech-surveillance-state>

and thermal imaging—are working hand in glove with their government to perfect facial recognition for profit and control. In this domain, there is no U.S.-China contest; the United States has essentially conceded the race because of concerns over the average individual’s privacy, and deep reservations about how this technology could be deployed. Westerners were alarmed in 2017 when researchers at Stanford created an AI algorithm that could detect with shocking accuracy individuals’ sexual orientation simply by scanning a single photo²⁴. It does not take much imagination to consider how less socially liberal governments would apply this technology. So while San Francisco recently banned facial recognition technologies, the Party has given China’s top four facial recognition firms access to its database of over 1.4 billion citizen photos. One well-informed venture capitalist in this arena estimates that Chinese facial recognition firms have 1 million times more images than their U.S. counterparts.

In speech tech, Chinese are beating American firms in all languages—including English. The world’s top voice recognition startup is China’s iFlytek. Its user base is seven hundred million, almost twice the 375 million people who speak to Apple’s Siri.²⁵ In system performance competitions, iFlytek regularly beats teams from Google, Microsoft, Facebook, IBM and MIT, all in its second language.²⁶ At Stanford’s international challenge for machine reading comprehension, Chinese teams won three of the top five spots, including first place. Baidu developed a human-level speech recognition system a year before Microsoft did.

Who was the U.S. Army’s major supplier of commercial drones until 2017—when the United States prohibited purchases for foreign suppliers?²⁷

24 The Stanford study found that a computer algorithm could distinguish between gay and straight men 81% of the time and 74% for women. The study was published in the *Journal of Personality and Social Psychology* and was based on around 35,000 images. Sam Levin, “New AI can guess whether you’re gay or straight from a photograph,” *Guardian*, September 7, 2017. <https://www.theguardian.com/technology/2017/sep/07/new-artificial-intelligence-can-tell-whether-youre-gay-or-straight-from-a-photograph>

25 “iFLYTEK, Asia’s AI Leader, Unveils iFLYTEK Translator 2.0, iFLYREC Series Voice-to-Text Products, AI Note and iFLYOS at CES 2019,” *Business Wire*, January 6, 2019. <https://www.businesswire.com/news/home/20190106005130/en/>

26 Peter Diamandis, “China Spotlight: Next AI Superpower?” *Tech Blog on Diamandis.com*, <https://www.diamandis.com/blog/rise-of-ai-in-china>

27 The US Army stopped using DJI drones after the National Defense Authorization Act included a provision to block the Defense Department from using Chinese drones. Bryan Pietsch, “Global drone market estimated to reach \$14 billion over next decade: study,” *Reuters*, July 17, 2019. <https://www.reuters.com/article/us-usa-security-drones/global-drone-market-estimated-to-reach-14-billion-over-next-decade-study-idUSKCN1UC2MU>

Shenzhen drone maker DJI, which controls 70 percent of the global market²⁸. Drones would be just miniature hobby helicopters without elementary AI, which gives them computer vision for targeting weeds or weapons, and enables them to operate in swarms. As the recent attack on Saudi Arabia's principal oil facilities demonstrated, the world has just begun to discover the security consequences of AI-enhanced drones operating literally below the radar. Of the world's top five commercial drones brands, 3 are Chinese; 1 American.²⁹

5G infrastructure will be the backbone that enables AI to reach further into everyday life, from automated cars to smart glasses. China's Huawei is the world's leading supplier of this telecom equipment. Not only does it own the Chinese market, which will be the world's largest, but its 28 percent global market share nearly equals the combined shares of its two top competitors.³⁰ Of the top four brands that will build 5G infrastructure, two are Chinese and zero are American. Chinese firms own twice as many 5G -essential patents as American firms. While the outcome of the current U.S. government campaign against Huawei remains uncertain, the company is currently delivering 5G systems well ahead of all competitors and is bringing a 5G phone to market a year ahead of Apple, the company that invented the iPhone.

Financial markets reflect these realities. Five years ago, two of the world's twenty most valuable internet companies were Chinese; today, nine are. The "Seven Giants of the AI age"—Google, Amazon, Facebook, Microsoft, Baidu, Alibaba and Tencent—are split on either side of the Pacific. Of every ten venture capital dollars invested in AI in 2018, five went to Chinese startups; four to American firms.³¹ Of the world's top ten AI startups, half are American and half are Chinese.

28 Alex Fitzpatrick, "DJI: The drone dominator," *TIME*. <https://time.com/collection/genius-companies-2018/5412498/dji/>

29 A report from CSIS lists the top 5 drone brands by global market share (2017). Of the 5, 3 are Chinese: DJI, Yuneec, and Syma, whereas only one—3D Robotics—is American. See China Power Team. "Is China at the forefront of drone technology?" *China Power*, May 29, 2018. <https://chinapower.csis.org/china-drones-unmanned-technology/>

30 Huawei holds 28% of global market share, while Nokia holds 17% and Ericsson 13.4%. Stu Woo, "Huawei Rivals Nokia and Ericsson Struggle to Capitalize on U.S. Scrutiny," *Wall Street Journal*, December 31, 2018. <https://www.wsj.com/articles/huawei-rivals-nokia-and-ericsson-struggle-to-capitalize-on-u-s-scrutiny-11546252247>

31 Jackie Snow, "China's AI startups scored more funding than America's last year," *MIT Technology Review*, February 14, 2017. <https://www.technologyreview.com/f/610271/chinas-ai-startups-scored-more-funding-than-americas-last-year/>

Chinese investments in AI research and development have surged to American levels, and the results are beginning to show it. The blunt truth is that China is laying the intellectual groundwork for a generational advantage in AI. According to the Allen Institute for Artificial Intelligence's authoritative assessment, China would overtake the United States in 2019 in the most-cited 50 percent of AI papers. It will take the lead in the most-cited 10 percent this year. And by 2025, the United States will fall to second in the top 1 percent of papers.³² (Fortunately, in breakthrough papers, China remains behind.) In public patents for AI technologies, China passed the United States in 2015, and in 2018 filed 2.5 times more than America.³³ In machine learning's hottest subfield—deep learning—China has six times more patent publications than the United States. (Raw numbers, however, must be taken with a grain of salt, since not all patents are equal.)

China is investing heavily in the necessary hardware as well. In 2001, China had none of the world's five hundred fastest supercomputers. Last year, it had 219 (the United States has 116).³⁴ And while China's supercomputers previously relied on American semiconductors, its top machine today was built entirely with domestically-manufactured processors.

Like Olympic athletes, AI researchers are eager to demonstrate their progress and prowess in international competitions. As mentioned earlier, in 2017, DeepMind's AlphaGo Master defeated the Go world's top champion Lee Sedol a decade sooner than experts had predicted. Eight months later, Tencent's own Go program, called "Fine Art," also beat Sedol. And Fine Art won despite giving Sedol a two-turn head start—a handicap DeepMind has been unwilling to offer.³⁵

Meanwhile, at the International Aerial Robotics Competition, the world's longest-running university robotics competition, the top three performers

32 Carissa Schoenick, "China May Overtake US in AI Research," *Medium*, March 13, 2019. <https://medium.com/ai2-blog/china-to-overtake-us-in-ai-research-8b6b1fe30595>

33 In 2018, China filed more than 30,000 public patents for AI, roughly a 10-fold jump in five years. Yuki Okoshi, "China overtakes US in AI patent rankings," *Nikkei Asian Review*, March 10, 2019. <https://asia.nikkei.com/Business/Business-trends/China-overtakes-US-in-AI-patent-rankings>

34 TOP500 Team, "China Extends Lead in Number of TOP500 Supercomputers, US Holds on to Performance Advantage," *TOP500*, November 18, 2019. <https://www.top500.org/news/china-extends-lead-in-number-of-top500-supercomputers-us-holds-on-to-performance-advantage/>

35 Tom Simonite, "Tencent Software Beats Go Champ, Showing China's AI Gains," *Wired*, January 23, 2018. <https://www.wired.com/story/tencent-software-beats-go-champ-showing-chinas-ai-gains/>

last year were all Chinese entries.³⁶ And in the world's most prestigious computer science competition for secondary school students, the International Olympiad in Informatics, Chinese have won eighty-four gold medals while Americans have won fifty-two.

Achieving this success in competitions reflects the investment China has made in cultivating talent. In AI, brain power matters more than computing power. China annually graduates four times as many STEM students than the United States (1.3 million vs. 300,000) and three times as many computer scientists (185,000 vs. 65,000). In the U.S. News & World Report ranks, China's Tsinghua University is number one in the world in computer science. Of every ten computer science Ph.Ds graduating in the United States today, three are American and two are Chinese. Three decades ago, only one of every twenty Chinese students studying abroad returned home. Now, four of every five do.³⁷

36 Mission 8 of the International Aerial Robotics Competition focused on Man-Unmanned Machine-Teaming. It was successfully completed in under 8 minutes by three teams: the Nanjing University of Aeronautics and Astronautics (NUAA); Sun Yat-Sen University; and Harbin Institute. <http://www.aerialroboticscompetition.org/mission8.php>

37 Wm C. Hannas and Huey-meei Chang from the Center for Security and Emerging Technology argue that "while cyber theft and industrial espionage may or may not be employed, we judge that the main practices enabling AI-related transfers are not illegal. This inspires optimism on one level, but many—possibly most— of these transfers are unmonitored and unknown outside China." Wm C. Hannas and Huey-meei Chang, "China's Access to Foreign AI Technology," Center for Security and Emerging Technology, September 2019. https://cset.georgetown.edu/wp-content/uploads/CSET_China_Access_To_Foreign_AI_Technology.pdf

Drivers of Competititon

Culturally, many Chinese embrace what many Americans see as a nightmare “surveillance state.” Even for applications that will clearly improve public health and safety, Americans are evenly split between those who are “very willing” and those who are “very unwilling” to share personal data. In China, the willing outnumber the unwilling five to one.³⁸ As an American-educated Chinese colleague observed, Chinese are as puzzled by Americans’ acceptance of monthly mass shootings as much as Americans are puzzled by Chinese acceptance of a government surveillance that keeps them and their families safe from such horrors.

China’s government, laws and regulations, public attitudes about privacy, and thick cooperation between companies and their government are all green lights for its advance of AI. In the United States and Europe, yellow and red lights abound. President Donald Trump’s statements about AI have essentially been rhetorical. In contrast, China’s president gets it. AI is a central pillar in his agenda to “make China great again.” In a process that reminds careful observers of the leadership of Amazon and Google, he has defined key performance indicators for its development, provided massive funding for specific projects, and done whatever possible to create favorable tailwinds. Wherever the Chinese government can protect companies (in its domestic market), support national champions (through subsidies and access to government data) and enable corporations leading AI charge, it does. It is ambitious performance targets that incentivize China’s fifteen cities with populations of more than 10 million and one hundred cities with populations of more than 1 million to compete in deploying sensors in highway systems (that will support driverless cars), cameras in the “sharp eyes” program that surveil public and private properties, and an array of similar collection technologies that create “smart cities.”

38 Per a GfK survey done in 2017, 38% of Chinese internet users age 15+ said they were willing to share personal data in exchange for benefits or rewards, while 8% said they were unwilling. In the US, 25% said they were willing, while 23% said they were unwilling. “Willingness to share personal data in exchange for benefits or rewards,” GfK, January 2017. https://www.gfk.com/fileadmin/user_upload/country_one_pager/NL/images/Global-GfK_onderzoek_-_delen_van_persoonlijke_data.pdf.

See also Mary Meeker, “Internet Trends 2018,” Kleiner Perkins Partner, May 30, 2018. <https://www.kleinerperkins.com/perspectives/internet-trends-report-2018/>

On each of these fronts, there are, of course, competing considerations. A more comprehensive net assessment would require drilling down at length in each area of competition. On the current path, we expect that, for the next decade, the United States will maintain its lead in enterprise software (e.g. business tools like automatic billing), advanced semiconductors and quantum computing. Nonetheless, assessing the rivalry in the decade ahead, we believe that the United States and China must be recognized as peer competitors. U.S. advantages include its position as first mover (that has allowed Facebook and Google to lead not just in American domestic markets but worldwide); the current cadre of superstars pushing the frontier of research; the ability and determination of Silicon Valley to recruit the 0.0001 percent most capable individuals from 7.7 billion people around the globe; and an ecosystem that actively encourages disruptive invention and innovation.

At the same time, American AI faces serious headwinds, including a culture that values privacy over security, distrusts authority and is suspicious of government; IT companies wary of working with the U.S. Defense Department and intelligence agencies; dysfunctional public policies inhibiting recruitment and immigration; laws that make it difficult to compile big data sets; and the prospect of further regulations and antitrust action against the companies that are now America's national champions—and are driving American advances in this arena.

In the longer-term competition, China's advantages begin with its population of 1.4 billion that creates an unparalleled pool of data and talent, the largest domestic market in the world, and information collected by companies and government in a culture that values security over privacy. Its commitment to education creates an army of less expensive labor willing and able to spend substantial amounts of time cleaning data sets. Its universities are graduating computer scientists in multiples of their American counterparts, all of them eager to develop algorithms to solve social problems. Because a primary asset in applying AI is the quantity of quality data, China has emerged as the Saudi Arabia of the twenty-first century's most valuable commodity.³⁹ The total data created, captured and copied in China is already far greater than in the United States. In addition, the country has hungry entrepreneurs like

39 See Kai-Fu Lee's *AI Superpowers* for further discussion of the role of data in AI development.

Alibaba's Jack Ma and Tencent's Pony Ma; a government that is leading a whole-of-nation campaign to become the world's leader in AI; and a national sense that China's time has come.

To the extent that the next decade is an era of implementation, the advantage lies with China. In implementation, the overwhelming competitive advantage is quantity of quality data. Both in collection and in having a cadre of grunts to clean the data, China wins. In contrast, though, if the most significant advances in AI in the next decade come from breakthrough leaps, like the development of deep learning, the advantage lies with the United States.⁴⁰ Both the fact that half the world's AI superstars work for American companies and that the United States can recruit from all the world's people—while inherent insularity restricts China to its own population—provide advantages Beijing cannot match.

40 For more information on the US advantage in making breakthroughs, see Carl Benedikt Frey and Michael Osborne, "China Won't Win the Race for AI Dominance," *Foreign Affairs*, June 19, 2020. <https://www.foreignaffairs.com/articles/united-states/2020-06-19/china-wont-win-race-ai-dominance>

A Marriage Made in Hell

It has long been an article of faith in the West that innovation, especially in information technologies, can only be advanced by free individuals operating in open societies, and that these advances inevitably enlarge individual freedoms. But as we are now seeing in social media, corporations and governments can employ these technologies to manipulate minds and abuse freedoms. China is demonstrating what is possible with a powerful positive feedback loop between its Party-led authoritarian operating system on one hand and advances in AI that strengthen central authority on the other. The brute fact is that AI is a powerful tool for autocratic control. Thus, from the perspective of all who believe that human beings are endowed with unalienable rights of “life, liberty, and the pursuit of happiness,” and that democracy is the best way to ensure those rights, China’s embrace of AI represents a marriage made in hell.

The United States will compete with China in applying AI across all domains, including the economy, military and society. But in governance, because of systemic differences between the two countries, the Party is running a leg of the AI race in which the United States has rightly chosen not to compete.

AI strengthens what the business historian Alfred D. Chandler, Jr. called the “visible hand.”⁴¹ Chandler was writing about corporations that, in the absence of legal constraints on predatory behavior and antitrust enforcement, create monopolies and oligopolies that dominate markets. Without the constraints Western constitutions place on government, the Party can use AI to control and dominate China in a way Americans would find unimaginable—and Soviet leaders only dreamed of.⁴²

41 Alfred Chandler, *The Visible Hand: The Managerial Revolution in American Business* (Cambridge: Belknap Press, 1977).

42 As the November 2019 report of the National Security Commission on AI stated, “We envision a world in which AI is used to prolong and enrich lives and make people smarter by giving them information they need when they need it. By contrast, we must avoid a future where AI contributes to a world of greater centralized control; empowers authoritarianism; is utilized as an instrument to repress dissent and impose conformity; destroys truth and trust within societies.”

The Chinese people have embraced their president's ambition to make China great again—in Xi's words, "the great rejuvenation of the Chinese people."⁴³ Xi believes that this requires revitalizing and revalidating the Party as the Leninist-Mandarin vanguard of the people. As he said in setting specific targets for 2021, 2035 and 2049 (the last being the one-hundredth anniversary of the People's Republic of China)⁴⁴: "Government, the military, society, education; north, south, east, west—the Party leads everything."⁴⁵ Advanced information technologies and AI are key components of this program.

Many of the same factors that have propelled the FAANGS to trillion dollar valuations in the American market are similarly strengthening the dominance of the Party in Chinese society. The basic principles of digitization and network theory that have driven the success of "hub firms" like the FAANGS and BATS are summarized by Professors Marco Iansiti and Karim R. Lakhani in their 2017 *Harvard Business Review* article, "Managing our Hub Economy."⁴⁶ First, Moore's Law (according to which computer processing power doubles every two years) leads to exponential productivity growth in activity in which computers are a key pillar. Compare the capabilities of the first iPhone, introduced just a decade ago, with what today's models can do. Second, Metcalf's Law, according to which the value of a network expands with the number of users, means that each additional user of Facebook or WeChat increases their value at no additional cost. Third, Barabási's Laws identify a positive feedback loop that produces highly-connected hubs: the more transactions that occur over a digital network, the greater the economic power of network hubs. In Iansiti's and Lakhani's summary: "Once a hub is highly connected (and enjoying increasing returns to scale) in one sector of the economy (such as mobile

43 Xi Jinping's phrase, "中華民族偉大復興," also commonly described as being part of the "China Dream."

44 Within a month of becoming China's leader in 2012, Xi specified deadlines for meeting each of his "Two Centennial Goals." First, China will build a "moderately prosperous society" by doubling its 2010 per capita GDP to \$10,000 by 2021, when it celebrates the 100th anniversary of the Chinese Communist Party. Second, it will become a "fully developed, rich, and powerful" nation by the 100th anniversary of the People's Republic in 2049. The midpoint, 2035, is the target for achieving "socialist modernization." If China reaches the first goal—which it is on course to do—the IMF estimates that its economy will be 40 percent larger than that of the U.S. (measured in terms of purchasing power parity). If China meets the second target by 2049, its economy will be triple America's.

45 "Full text of Xi Jinping's report at 19th CPC National Congress," *Xinhua*, November 3, 2017. http://www.xinhuanet.com/english/special/2017-11/03/c_136725942.htm

46 Marco Iansiti and Karim R. Lakhani, "Managing Our Hub Economy," *Harvard Business Review*, September-October 2017. <https://hbr.org/2017/09/managing-our-hub-economy>

telecommunications), it will enjoy a crucial advantage as it begins to connect in a new sector.” Financial payments provide an instructive example.⁴⁷

Consider Facebook’s business strategy. By creating a user-friendly platform in which 2.4 billion individuals freely share their lives with family and friends, Facebook collects intimate data that allows it to understand who its users are, what they care about, what they believe deserves to be shared with someone else, and what turns them on and off. This allows them to charge premium prices for micro-targeted ads seeking to persuade specific viewers to buy a product, idea or even a candidate. In Mark Zuckerberg’s succinct summary: “Because we understand what you’re interested in, we can show you more relevant ads.”⁴⁸

Amazon also offers telling clues to ways Xi could use AI to address his most existential threat—opposition from within—by tightening his grip on the Party. Despite their differences, Xi and Amazon CEO Jeff Bezos have one key challenge in common: how to recruit, retain and manage members for organizations of unparalleled scale. For Xi, it’s the Party’s ninety million members. For Bezos, it’s the one hundred million plus members of Amazon Prime. In both cases, members are scattered across a vast geography, pay annual dues and can leave if they want—so they need a return on their investment. For both leaders, maintaining loyal membership while crushing competition are vital to their organization’s long-term success. To the frustration of those who confidently and repeatedly predict that each will fail, we note that, so far, both seem to be thriving.

AI is Amazon’s secret sauce. As Bezos says candidly: “Machine learning and artificial intelligence are behind almost everything we do...”⁴⁹ The company’s algorithms give Prime members more of what they want (via suggestions), help Amazon learn actionable details about members (via detection of browsing and purchase patterns), streamline logistics to deliver on promises across all geographies and catch rule-breakers. And if

47 In a more recent article by Iansiti and Lakhani, they propose the concept of the “AI factory,” a decision-making entity present in companies with AI capabilities. Marco Iansiti and Karim R. Lakhani, “Competing in the Age of AI,” *Harvard Business Review*, January-February 2020. <https://hbr.org/2020/01/competing-in-the-age-of-ai>

48 Kara Swisher, “Zuckerberg: The Recode Interview,” *Vox*, October 8, 2018. <https://www.vox.com/2018/7/18/17575156/mark-zuckerberg-interview-facebook-recode-kara-swisher>

49 “Amazon sets conference on robotics, artificial intelligence,” *France24*, January 17, 2019. <https://www.france24.com/en/20190117-amazon-sets-conference-robotics-artificial-intelligence>

Bezos is not already, he will soon be using AI to crawl the web for traces of dangerous upstarts that might disrupt his organization—and act to prevent them from succeeding.

Which of these tools will Xi's China not be using? While AI will boost venture capital returns and military capabilities on both sides of the Pacific, it profoundly strengthens the governance system in only one country.

An AI Arms Race?

During the Cold War, the stakes in the nuclear arms race with the Soviet Union were obvious. In today's Thucydidean rivalry between a meteorically rising China and a colossal ruling United States, what are the risks of an escalating AI arms race?

Like it or not, future war will be AI-driven. As Secretary of Defense Mark Esper recently noted at the conference of the National Security Commission on AI, "Advances in AI have the potential to change the character of warfare for generations to come. Whichever nation harnesses AI first will have a decisive advantage on the battlefield for many, many years."⁵⁰ AI's ability to accelerate decision cycles in conflict will compel militaries to adopt it. In air-to-air combat, pilots begin with an OODA loop: observe, orient, decide, act. If A can "get inside B's OODA loop," A wins—since he can maneuver to escape A's fire and attack where he calculates B's path will leave him when A's missile arrives. Because AI can observe, orient, decide and act at multiples of a human pilot, it will become irresponsible to send a human pilot into battle with an AI piloted aircraft.⁵¹ As former Chairman of the Joint Chiefs of Staff Joseph Dunford put it: "Whoever has the competitive advantage in artificial intelligence and can field systems informed by artificial intelligence, could very well have an overall competitive advantage."⁵²

The demonstrated success of AlphaGo, and more recently, AlphaStar, in defeating all competitors in one of the world's most complex real-time strategy video games suggests that in any structured contest between offense and defense, AI will dominate humans. The company, country or

50 The US Department of Defense, "Remarks by Secretary Esper at National Security Commission on Artificial Intelligence Public Conference," November 5, 2019. <https://www.defense.gov/Newsroom/Transcripts/Transcript/Article/2011960/remarks-by-secretary-esper-at-national-security-commission-on-artificial-intell/>

51 As the November 2019 report of the National Security Commission on AI stated, "AI adoption for national security is an urgent imperative. We see no way to protect the American people, US interests, and shape the development of international norms for using AI if the United States is not leading the way in application."

52 General Joseph Dunford (now Senior Fellow at the Belfer Center) in an interview with David Ignatius of the *Washington Post*. "Gen. Joseph Dunford on artificial intelligence and the future of the U.S. military," *Washington Post*, December 6, 2018. https://www.washingtonpost.com/video/postlive/gen-joseph-dunford-on-artificial-intelligence-and-the-future-of-the-us-military/2018/12/06/fb-c507d0-ddb1-4f45-b8b6-54d501265846_video.html

team with the best AI will win. As an example, consider American football. In what commentators often discuss as a “chess match,” the offense and defense coordinators know that if the defense guesses correctly whether the next play will be a pass or a run, most NFL teams’ defenses can successfully stop most opponents’ offense. Reading all the variables in a situation, AI should be able to tilt the scales on the field—or in analogous military competitions on land, sea, and in the air and space.

The domain’s leader will also be the first to know which of today’s military mainstays AI will upend. Germany discovered the power of submarines before World War I because it led in their development. British admirals did not wake up to their deadly efficiency until a lone German U-boat in 1914 sank three armored cruisers on a single morning. By then, it was too late—the British had already invested their treasure in building battle fleet that had become largely obsolete. The coordination of drones and cruise missiles that successfully attacked Saudi Arabia’s most valuable target and cut its oil exports by half is suggestive. Will AI-empowered drone swarms make aircraft carriers equally obsolete, all for one one-thousandth of the cost? Will AI analysis of data from all sources pierce the invisibility of stealthy systems like the F-35 in which the United States has invested so substantially? The first country to know will be the one driving the research and development frontier.

As we try to think about the path of unconstrained competition, five unanswered questions leave us uneasy. First, could the creation of machines a thousand times smarter than humans lead to any one of the cataclysmic dystopias now popular in sci-fi? We have seen numerous examples, from Skynet in “Terminator,” a self-aware network that decides to kill, to artificial general intelligence that outwits humanity to reverse the relationship between commander and commanded. We are skeptical. But we are also aware that we have watched what we once thought were clear distinctions between sci-fi and fact erode faster than we could have imagined.

Second is “Kissinger’s Specter.” As admirers of America’s greatest living statesman, we have been inspired by the readiness of someone who recently turned ninety-seven to try to understand enough of the technology to think seriously about its implications. In his words, “The Age of

Reason originated the thoughts and actions that shaped the contemporary world order. But that order is now in upheaval amid a new, even more sweeping technological revolution whose consequences we have failed to fully reckon with...”⁵³ We underline the question he poses: “Will AI, left to its own devices, inevitably develop slight deviations that could, over time, cascade into catastrophic departures?”⁵⁴

Third, should the current stage of the AI race in which the United States and China are peer competitors be recognized as a second “Stimson moment?” In the same month he dropped the first atomic bomb on Hiroshima, President Harry Truman recognized that America’s atomic monopoly would be fleeting. Fearful that a nuclear arms race with the Soviet Union could end in nuclear Armageddon, he asked his Secretary of War, Henry Stimson, to think seriously about sharing this monopoly with the emerging Soviet adversary. That effort failed. A similar effort to find ways in which the United States and China could jointly develop military applications of AI might also founder. But given the risks, shouldn’t we explore an analogous effort?

Fourth, if an AI race between the United States and China essentially follows the path of the U.S. and Soviet rivalry in developing and deploying nuclear weapons, is there likely to be a plateau equivalent to MAD: mutual assured destruction? As each superpower in the nuclear race rapidly acquired a robust second-strike arsenal, they found themselves locked in a stalemate. Neither could launch a nuclear attack on the other without triggering a response that would destroy itself. Technology thus created an overriding shared interest in avoiding the nuclear war of which both would have been the ultimate victims. Despite its high costs and extreme risks, this condition contributed to a certain caution and stability in the “long peace” of the past seven decades without great power war. In AI, we have not been able to identify any analogous plateau.

53 Henry A. Kissinger, “How the Enlightenment Ends,” *The Atlantic*, June 2018. <https://www.theatlantic.com/magazine/archive/2018/06/henry-kissinger-ai-could-mean-the-end-of-human-history/559124/>

54 As Tim Cook, CEO of Apple, has warned, “For artificial intelligence to be truly smart, it must respect human values, including privacy. If we get this wrong, the dangers are profound.” Sam Shead, “Apple CEO Tim Cook Issues AI Warning: ‘It Must Respect Human Values, Including Privacy.’” *Forbes*, October 24, 2018. <https://www.forbes.com/sites/samshead/2018/10/24/apple-ceo-tim-cook-issues-ai-warning-it-must-respect-human-values-including-privacy/#4e1bea20584d>

Fifth, are there unrecognized shared interests between the United States and China that should lead them to adapt and apply lessons from the Cold War? Through a series of close calls, including the Cuban Missile Crisis, the nuclear superpowers discovered their mutual interest in preventing misperceptions, misunderstandings and accidents from dragging them into a war they were determined to avoid. They developed new ways to communicate (the hotline), to constrain deployments of particular weapons (arms control treaties), and even to cooperate in preventing other nations or terrorists from acquiring nuclear weapons (the Treaty on the Non-Proliferation of Nuclear Weapons). As the United States searches for a viable strategy to establish and sustain a position of leadership in AI, we believe that the risks inherent in an unconstrained AI race should motivate far-sighted Americans and Chinese to seriously explore together potentially safer alternatives, perhaps in the process helping to shape a new U.S.-China relationship.

Clues for a Winning Strategy

Is AI a race China is destined to win? With a population four times the size of the United States, there is no question that China will have the largest domestic market for AI applications. With many multiples of the United States in data, substantially larger numbers of computer scientists and a government for which there is a first-order priority, we can understand colleagues who are pessimistic. Indeed, it is our best judgment that on the current trajectory, while the United States will maintain a narrow lead over the next five years, China will then catch up and pass us quickly thereafter.

Nonetheless, we believe that this is an arena in which the United States can compete—and win. Congress recently established the “National Security Commission on Artificial Intelligence,” with Eric Schmidt as its chair, and Bob Work, who served as Deputy Secretary of Defense under both Obama and Trump, as Vice Chair. Its mission is to develop that strategy “to ensure America’s national security enterprise has the tools it needs to maintain U.S. global leadership.”⁵⁵ In the hope of being helpful to that effort, we conclude with five pointers toward a winning strategy.

First, Americans must wake up to the challenge. Recognition that that the United States faces a serious competitor in a contest in which the outcome will be decisive for our future is necessary to get our competitive juices flowing. The Olympics offers an instructive analogy for thinking about a competitive strategy for AI. It also reminds us that competition is inherently a good thing. Competition produces superior performance. Participants in a marathon run faster than they do when running alone. Indeed, competition is a core American value. Free markets organize a competitive process that produces better products at cheaper prices. Science and its applications advance as research teams compete to better understand the world.⁵⁶

55 The Commission has released a preliminary report in July 2019 and an interim report in November 2019. It plans to release a final report in March 2021, along with several recommendations before then. <https://www.nsc.ai.gov/>

56 As the November 2019 report of the National Security Commission on AI stated, “The choice need not be a binary one between cooperating and disentangling.”

Second, in this competition, the United States cannot hope to be the biggest—in that category, China wins by default due to the size of its population. However, what the United States *can* be is the smartest. In the seeking to improve and advance the most advanced of technologies, the brightest 0.0001 percent of individuals make the difference. The United States can succeed by recruiting talent from all 7.7 billion people on Earth and enabling these individuals to realize their full potential.⁵⁷ In fact, U.S. companies have now recruited more than half of the top 100 recognized AI geniuses. In sharp contrast, China is a closed society—limited essentially to 1.4 billion Chinese speakers. Just 1000 foreign born individuals became Chinese citizens last year. So while the United States will not win competitions in which bulk numbers are the dominant factor, where brilliance, creativity and innovation matter most, the United States has a decisive advantage.⁵⁸

Third, platforms matter. Here the United States begins with a huge sustainable competitive advantage: English is the universal language for science, business and the web. Chinese face the choice of either speaking English, or simply talking to themselves. Not only do the Chinese, but also the French and others often complain that this is unfair—and it may be. But it is a fact. To transform Singapore from a third-world city into one of the world's most successful and prosperous global trading hubs, Lee Kuan Yew insisted on making English its first language. (Indeed, at one point in counseling Chinese leaders, he suggested that China make English its first language.) Today, more than half of the 7.5 billion people on Earth speak English—and another billion are seeking to learn.

Fourth, American companies have a significant first mover advantage in the establishment of the major platforms in AI, including operating systems (Android and Apple), design of advanced semiconductors (ARM), and killer apps—including Instagram, YouTube and Facebook. Instagram

57 The November 2019 NSC-AI report argued, "Actions taken to protect America's AI leadership from foreign threats must preserve principles of free inquiry, free enterprise, and the free flow of ideas."

58 A report by the Center for Security and Emerging Technology found that internationally the US faces increasing competition for talent. The authors argued that policymakers "need to reform high-skill immigration rules in order to maintain and improve U.S. international AI talent retention" and should "address legitimate security concerns around foreign AI talent while avoiding broad and potentially counterproductive restrictions." Remco Zwetsloot, James Dunham, Zachary Arnold, and Tina Huang, "Keeping Top AI Talent in the United States," Center for Security and Emerging Technology, December 2019. <https://cset.georgetown.edu/wp-content/uploads/Keeping-Top-AI-Talent-in-the-United-States.pdf>

has 1 billion monthly active users; Facebook more than 2.4 billion. While Chinese competitors will certainly attempt to displace the current leaders in both platforms and applications, if American companies are smart enough to continue enlarging their users' opportunities, improving their experiences, and expanding the number of people using their platforms and applications, Chinese and others who want to speak to the world could have to continue relying on U.S.-dominated platforms.

Fifth, while competing vigorously with the intention of sustaining U.S. leadership, we must recognize at the same time the necessity of cooperation in areas where neither the United States nor China can secure its own minimum vital national interests without the help of the other. The consequences of human energy consumption on the climate offers a vivid illustration. If either the United States or China keeps emitting greenhouse gases at the current rate, in one hundred years, this could produce a biosphere in which neither nation can survive. Thus there is no viable alternative to cooperation. The same is true in other realms including preventing third party provocations—for example, in North Korea or Taiwan—from dragging the United States and China into a catastrophic war; and cooperation to prevent recurring financial crises like the Great Recession of 2008 from cascading into another Great Depression. We suspect there may be an analog in limiting the unconstrained advance of AI.

The possibility that nations could simultaneously compete ruthlessly, on the one hand, while cooperating intensely, on the other, sounds to diplomats like a contradiction. In the world of business, however, it is called life. While no one has yet developed a felicitous term for what is sometimes called “coopetition,” Apple and Samsung offer a powerful example. The two are ruthless rivals in the global market for smartphones (where, in fact, over the past five years Samsung has become number one). But who is Apple's largest supplier of components for smartphones? Samsung. Managing a relationship that is simultaneously competitive and cooperative requires vigilance, judgment and agility in adapting. But if, as we believe the evidence shows, technologies on a small globe have left the United States and China with two—and only two—options, we believe they can find ways to coexist, however uncomfortably, if their only alternative is mutual destruction.



Preventing Great Power War Project

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