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FROM RIDING A WAVE TO FULL STEAM AHEAD

As China's Government Mobilizes for AI Leadership, Some Challenges Will Be Tougher Than Others

By Paul Triolo and Jimmy Goodrich

The Chinese government has set high ambitions for national development in artificial intelligence technologies. Its July 2017 New Generation Artificial Intelligence Development Plan (AIDP), translated by DigiChina, set the attention-grabbing goal of building China into the "world's primary AI innovation center" by 2030. Well before the government set targets, Chinese tech giants had invested great time and treasure in AI technology development, but now the bureaucracy is lurching into motion to support an effort far broader than the coattails of industry leaders. This essay, by two experienced analysts of Chinese digital technology development, chronicles the government's initial efforts to achieve its declared goals, assesses Chinese potentials in core AI technologies, and anticipates the coming efforts by government and private actors. –Ed.

About DigiChina

New America's DigiChina project is a collaborative effort to understand China's digital policy developments, primarily through translating and analyzing Chinese-language sources. How the Chinese state and society deploy and use digital technologies is increasingly consequential for governance, markets, and security around the world. From laws and regulations to published commentaries from policymakers and corporate strategies, China's public sphere provides a great deal of insight into what's happening and why. DigiChina contributors, working collaboratively with industry and policy experts around the globe, work innovatively to bring that insight to an international audience and better inform important debates and decisions. Read more at: https://www.newamerica.org/cybersecurity-initiative/digichina/

I. Introduction

One of the most significant developments in the artificial intelligence (AI) world in 2017 was the release of China's New Generation Artificial Intelligence Development Plan (AIDP) in July. The plan has generated a great deal of media and analyst attention, with numerous unfounded reports that China has "surpassed the United States" or is "leading in AI globally." While China certainly has a large and talented workforce, ample capital to deploy, and increasingly innovative firms, it still lags behind the United States in many important indicators. Those include advanced university AI programs, qualified faculty, overall numbers of AI companies, and companies capable of producing cutting-edge semiconductors for AI applications. In fact, China's leaders are soberly aware that their nation risks remaining behind in developing potentially transformative technologies. The Wuzhen Institute, a government-connected think tank, noted in January that "China still lags behind the United States in most AI indicators, such as private investment and the number of patents."

There was much made in the media of China's ambitious plans laid out in the AIDP, most eye-catching being a call for China to lead the sector globally by 2030. DigiChina's initial assessment of the plan, accompanied by a full translation, also highlighted some of its more concrete ambitions and less flashy goals, such as a call to develop a regulatory environment around AI. Since the release of the plan, official Beijing has amped up its rhetoric on the importance of AI development. President Xi Jinping referenced AI in his work report to the 19th Party Congress in October, and the government-hosted World Internet Conference in Wuzhen, Zhejiang, featured AI prominently in December. More subtle, Xi's 2018 New Year's greeting video featured two leading books on AI on his bookshelf. And in early January, Beijing announced plans to establish a major AI park in the Zhongguancun area, already home to dozens of major Internet and high-tech companies.

This essay describes a wide range of moves since July that at least appear to represent a whole-of-government push to achieve some kind of "leadership" in AI by 2030. But questions remain. How much of a difference will having a strategy, plans, dedicated parks, and special funding make in Chinese efforts to develop and deploy AI? Will the government's AIDP suffer the fate of previously announced "whole-of-government efforts" to develop technologies like "big data" (2013) and "the internet of things" (2008) that have appeared to peter out into a regulatory abyss? By analyzing the role of the private sector,

international ties to AI communities in the United States and elsewhere, and the challenge of developing world-leading semiconductors, we argue that Chinese government efforts to drive AI development so far are actually riding a wave of private sector development well under way, but that significant challenges and uncertainties remain. Specifically, we argue that Chinese efforts are still significantly behind U.S. and other leading efforts in core research and technologies related to AI, such as academic theory and core semiconductors. Indeed, Chinese planners recognize these gaps, as the thrust of their government efforts are targeted toward these two areas.

II. Planning for Success: Establishing Supporting Structures for AI Development

As in many other areas, Chinese government leadership on AI at least nominally comes from the top. Xi has identified AI and other key technologies as critical to his goal of transforming China from a "large cyber power" to a "strong cyber power" (also translated as "cyber superpower"), and he is personally involved in technology development and governance issues. In view of the fact that large data sets can be critical to achieving AI breakthroughs, Xi in December chaired a Politburo study session on "implementing a national big data strategy," where he called for greater sharing of data sets among government agencies and sectors of the economy. Indeed, it is likely that the earlier lackluster big data strategy has been incorporated into the present AI push and the two are now considered to be part of the same strategic set of goals. Xi's expressed interest in AI and other related technology issues drive the Chinese government to view these "mission-oriented" industrial policies as not only important for the Chinese economy, but politically important as well. Officials across a large number of national, local, and functional organizations have begun to implement plans designed to fulfill the Xi-backed vision of the AIDP.

A. National initiatives

In the months following the issuance of the July 2017 AIDP, the major Chinese bureaucratic players behind it have all taken steps to begin implementation by issuing documents, organizing meetings, and establishing new bodies to oversee and guide AI development in China.

Within the Politburo, Xi initially delegated oversight over China's AIDP to State Councilor Liu Yandong, who has the science and technology portfolio. Liu, like her likely successor Sun Chunlan, possesses little background in technology issues and relies on the science agencies within the State Council for detailed policy setting and implementation. Under direction of the Politburo, the State Council formalized roles and responsibilities for AI development in September 2017 through the establishment of the **New Generation Artificial Intelligence Development Plan Implementation Office (AIDP Implementation Office)**, led by the **Ministry of Science and Technology (MOST)**, with 15 other agencies participating. The responsibility of the MOST-led office is to coordinate inter-ministry implementation of the AIDP, including large-scale AI-related science and technology (S&T) megaprojects, and to lead interaction with major private sector players. That public-private coordination is crucial, given the leading role played by large Internet firms in the development of most already-deployed AI applications.

MOST was designated the lead on China's AIDP given its role in earlier S&T programs related to AI. It has overseen large development projects such as the 863 and 973 Programs—focused on applied and basic research, respectively—which have produced progress on some of the technologies underlying AI. MOST is a relatively small ministry within China, with a smaller number of subordinate or associated industry organizations or state owned enterprises, but it controls most central government R&D funding, has asserted itself in the AI arena, and will continue to be an important player going forward. One of MOST's subordinate organizations, the Natural Science Foundation, responsible for basic research funding, is also re-directing resources towards basic S&T research in AI-related fields.

In November MOST also announced the establishment of the **New Generation AI Strategic Advisory Committee**, headed by Pan Yunhe, an academician at the Chinese Academy of Engineering (CAE) and a specialist in advanced manufacturing. Pan is a deputy chairman of the **China Association for Artificial Intelligence (CAAI)**, an academic body that holds conferences on AI and includes all the major academic players on AI in China. The committee is heavy on academicians, with specialities spanning automation, robotics, machine learning, facial recognition, and other AI disciplines. It also includes specialists in civilian-military integration, reflecting the Chinese military's interest in AI. Finally, the committee incorporates representatives from the four AI "National Team" companies named by MOST last year (Alibaba, Baidu, Tencent, and iFlytek), and one from Horizon Robotics, which is developing AI chips for autonomous vehicles and other applications. It is likely that other private sector members will be added to this body in the course of 2018, in

part to balance the heavy government membership and better reflect the critical role the private sector and startups are playing in the sector.

Figure 1: New Generation AI Strategic Advisory Committee

Name		Affiliation	Focus
Pan Yunhe	潘云鹤	CAE Academician, Deputy Chairman, CAAI	CAD/CAM, advanced manufacturing
Chen Chun	陈纯	CAE Academician, Zhejiang University Professor	CAD/CAM, AI, mobile databases
Li Wei	李未	CAS Academician, former President, BUAA	Software development, AI, IC design
Gao Wen	高文	CAE Academician, Peking University, NSFC deputy director	AI Application, Visual Processing, Facial Recognition
Zheng Nanning	郑南宁	CAE Academician	Visual Processing, AI control system
Wu Cheng	吴澄	CAE Academician	Industrial Automation, AI Application
Li Bohu	李伯虎	CAE Academician	NLP
Lu Yueguang	吕跃广	CAE Academician, PLA GPD, Deputy Chairman	Civil-military integration, info. processing
Mei Hong	梅宏	CAE Academician	Software Development, NLP
Cao Xuetao	曹雪涛	CAE Academician, PUMC Chairman	Immunology
Wang Tianran	王天然	CAE Academician	Automation, Intelligent Robot
Lu Jian	吕建	CAE Academician, CCF Director	Machine Learning, Software Development
Wu Zhiqiang	吴志强	AIA Fellow, IVA Academician	Urbanization, City Planning
Huang Ru	黄如	CAE Academician, Peking University	Nano Semiconductor
Liu Ming	刘明	CAE Academician	Microelectronics Technology
Xu Zongben	徐宗本	CAE Academician	Machine Learning, Visual Processing
Wu Manqing	吴曼青	CAE Academician, China Electronics Science Academy Chairman	Defense electronics
Xu Bo	徐波	CAS Chair	Automation, Language Processing
Li Bin	李斌	CNITSEC, Assistant to the Director	Cybersecurity
Zhao Chunjiang	赵春江	NERCITA Chair	Intelligent Agriculture
Liu Zhong	刘忠	NUDT, Key Laboratory of Information Systems Engineering	Intelligent systems
Xue Lan	薛澜	Tsinghua University Professor	Technology Globalization, Innovation
Min Wanli	闵万里	Alibaba, Principle Data Scientists (Little Ai)	Fmr. IBM, Google, Alibaba ET Medical Brain project
Wang Haifeng	王海峰	Baidu, Chief, AI Group, Head, Baidu Research	ML, big data, computer vision, NLP, speech, AR
Yao Xing	姚星	Tencent, Vice President	Tencent Online Media Group, Data Mining
Hu Yu	胡郁	iFlytek, Senior VP, Research Institute, President	Voice recognition
Yu Kai	余凯	Horizon Robotics, Founder and CEO	Former Baidu, Chief, Embedded AI solutions

Key: AIA = American Institute of Architects; BUAA = Beihang University; CAD/CAM = computer-aided design and manufacturing; CAE = Chinese Academy of Engineering; CAS = Chinese Academy of Science; CCF = China Computer Foundation; CNITSEC = China Information Technology Security Evaluation Center; IC = integrated circuit; IVA = Royal Swedish Academy of Engineering Sciences; NERCITA = National Engineering Research Center for Information Technology in Agriculture; NLP = Natural Language Processing; NUDT = National University of Defense Technology; NSFC = National Natural Science Foundation of China; PLA GPD = People's Liberation Army General Political Department; PUMC = Peking Union Medical College.

While MOST has the nominal lead, other government bodies are equally influential, particularly the powerful **National Development and Reform Commission (NDRC)**. The NDRC remains important and, along with the Ministry of Finance, is responsible for long-range planning and overall investment levels in key high-tech sectors. Most importantly, it has broad discretionary spending authority, allowing it to quickly provide subsidies in the form of grants to domestic AI-related firms. It also has a hand in foreign investment decisions in the high-tech sector, both inbound and outbound, and retains clout within China's cyberspace and high-tech interagency processes.

In October the NDRC announced the establishment of the **China AI Industry Development Alliance**, which includes leadership from NDRC, MIIT, and subordinate institutes such as the China Academy of Information and Communications Technology (CAICT). The alliance will reportedly focus on "building a public service platform for the development of the artificial intelligence industry, integrating resources of the whole industrial chain, and accelerating the healthy and rapid development of China's artificial intelligence industry." The coalition includes over 200 companies, including Baidu, Alibaba, Tencent, telecommunications carriers, and cloud services providers. The alliance, which is to be overseen by NDRC, MIIT, MOST, and the Cyberspace Administration of China (CAC), will serve as another communication channel between the key government ministries involved in implementing aspects of the AIDP, and it broadens the focus of AI development across all key affected sectors. Still, its true importance is hard to predict: Such alliances exist within many other technology sectors in China and have a mixed record of effectiveness, particularly when it comes to influencing government policy and regulatory approaches.

Other institutions and ministries will also play a role both as regulators of AI applications, and as users. These include:

- **Ministry of Industry & Information Technology (MIIT):** MIIT is responsible for industrial policy for both new and traditional industries such as manufacturing, telecoms, and electronics, and AI clearly falls under MIIT's purview as part of programs such as Made in China 2025, which now has a major AI focus to help spur growth of intelligent manufacturing and the industrial Internet of Things. MIIT has also historically overseen parts of the semiconductor and software industries, both of which figure importantly in AI development. See DigiChina's full translation of MIIT's Three-Year Action Plan for Promoting Development of a New Generation Artificial Intelligence Industry (2018–2020), published in late 2017.

- **Cyberspace Administration of China (CAC):** Compared to the big three ministry-level players on AI, CAC will have less of a role and lower levels of influence as it relates to industry development. Rather it will focus primarily on the legal, regulatory, and standards issues surrounding AI and big data. In addition, CAC will have a role in the use of AI in cybersecurity applications, and in increasingly important areas related to AI such as data privacy, data protection, and transfers of data across borders, which will be of particular concern in contexts such as autonomous vehicles.
- **Ministry of Public Security (MPS):** Public security authorities are already deploying AI-based facial recognition systems nationwide for law enforcement purposes. Politburo member and law enforcement czar Meng Jianzhu in September highlighted the importance of "deploying AI for improving (the state's) predictive and warning capabilities" in the field of "social stability management."
- **People's Liberation Army (PLA):** The PLA is heavily involved in China's AI effort, with three separate organizations sitting in the AIDP Implementation Office. The PLA's primary interest is in ensuring that AI-related innovations in the private sector are rapidly assimilated and adopted by the Chinese military. The PLA also has its own S&T-related research programs that work directly on AI. Shortly before the AIDP was released, Chinese military experts proclaimed that AI is "China's most important dual-use technology."
- **Ministry of Health:** Public health authorities will be involved in regulatory issues related to the use of AI for medical applications, such as medical imaging and diagnostics.

B. Local governments aggressively push AI development

A number of large municipalities, including Beijing, Shanghai, Tianjin, Chengdu, and Wuhan, have also issued AI development plans and strategies, echoing in most cases the themes and priorities laid out in the national plans, and highlighting local advantages in AI-related sectors and technologies (see Figure 2). Shanghai in particular has been active and appears to hope to rival Beijing as a center of AI R&D and application within China. In November the **Shanghai** government issued its own implementation plan for new generation AI, and in December it announced a major agreement with 15 leading AI organizations covering most of the AI stack to launch an AI cluster in the city. Shanghai's Lingang Area Development Administration signed agreements with firms including Baidu Innovation Center, iFlytek, Horizon Robotics, and Cambricon.

Not to be outdone, **Beijing** in early January announced that a major new AI-focused industrial park would be constructed in Mentougou District. This announcement may not significantly affect the AI sector in Beijing or China more generally, however, as there do not appear to be major resources behind the effort, and AI companies will prefer to put facilities in places that already have a vibrant AI ecosystem like Beijing's Zhongguancun district, Shanghai, and Hangzhou. Beijing is already home to more than 10 national labs doing AI research, including the State Key Laboratory (SKL) of Pattern Recognition, the SKL of Intelligent Technology and Systems, and the Deep Learning National Engineering Lab (with Baidu). Beijing also boasts 160 of the country's 400 AI startups, according to industry reporting.

The Shanghai-Hangzhou area and Shenzhen will also attempt to attract AI engineers and entrepreneurs. When it begins to get off the ground around 2020, the planned high-tech city south of Beijing in the **Xiong'an New Area (XANA)** will also likely be a hub for deployment of systems leveraging AI. Alibaba is soon to begin building out part of the data center infrastructure in XANA, which will become a showcase for smart city applications such as autonomous driving.

Several provinces are now in the "study mode" as they determine what role they could plan in implementing the national plan, leveraging local academic organizations and attempting to attract talent. Provinces that have published initial AI policy documents include: Guangdong, Fujian, Hubei, Jiangsu, Jiangxi, Liaoning, among other localities.

Figure 2: Major Chinese national and local government strategy and policy documents related to AI and automation (2015-2017)

Name	*Issuer*	*Date*	*Focus*
Made in China 2025	State Council, MIIT lead	May 2015	Smart manufacturing, robotics, semiconductors
Internet+ Action Plan	State Council, NDRC, MIIT, MOST, CAC lead	July 2015	Internet access for industry, leveraging AI to create new services and applications, fostering AI backbone enterprises
Internet+ and AI Three-Year Action Plan	NRDC	May 2016	Developing basic AI ecosystem and producing world-class AI enterprises
New Generation Artificial Intelligence Development Plan (AIDP)	State Council, MOST lead	July 2017	Lays out roadmap for China to dominate AI sector globally by 2030
Application Guidelines for 2017 Projects on Key Topics, such as Intelligent Robotics	MOST	July 2017	Announces performance targets for 2017 projects involving sectors such as AI-driven robots
AI Innovation and Development Megaproject Application Requirements	NDRC	Oct. 2017	Details project requirements for 2018 in AI areas, including facial recognition, AI semiconductors
Implementing Opinions on Shanghai's	Shanghai Municipal	Nov. 2017	Details city focus on smart cars, robots, software

Promotion of New Generation AI Development	Government		platforms, AI semiconductors, smart sensors
Some Policies for Promoting Development of the AI Industry	Wuhan Donghu High-tech Development Zone	Nov. 2017	Establishes special fund to provide 200 million RMB/year for talent recruitment, innovation
New Generation AI Development Plan Implementation Kickoff Meeting	MOST, 15 ministries, commissions	Nov. 2017	Announces AI Strategic Advisory Commission, AIDP Implementation Office
Establishment of China AI Industry Development Alliance	NDRC	Nov. 2017	Establishes leadership team that includes Baidu, Unicom, ZTE, iFlytek, AIspeech, Sysware, Haier, Huawei
A Three-Year Action Plan for Promoting Development of a New Generation Artificial Intelligence Industry (2018-2020)	MIIT	Dec. 2017	Detailed new guidelines based on the National AI Strategy

Sources: State Council, MIIT, NDRC, authors

III. The Role of the Private Sector: Primary Driver, Primary Beneficiary

In China, large private sector companies such as Alibaba, Tencent, and Baidu have been pursuing investments in AI since well before the AIDP was announced. While they have benefited from increased government and investor interest in their AI efforts, the big three have largely shown deference to the plan and its various manifestations as they continue to pursue their pre-existing AI-related business initiatives. These companies, along with facial recognition giant iFlytek, were named in November to the first AI "National Team" and assigned to take the lead in establishing key "platforms" to pursue development under the AIDP: Alibaba for smart cities ("city brains"), Tencent for medical imaging, Baidu for autonomous vehicles, and iFlytek for voice recognition. None of these are new initiatives, yet officials in Beijing appear keen to take credit for them. These four will be the first of a larger set of companies likely to be named to the AI national team in 2018.

The emphasis that each will pursue includes developing open platforms for AI applications, which other companies will be able to leverage to develop a range of products and services. These companies maintain extensive R&D facilities that are not matched within leading government research organizations such as the Chinese Academy of Sciences. Increasingly they are also located both in the United States and China. For instance, **Baidu**'s growing suite of AI organizations includes its Augmented Reality Lab, Natural Language Unit, AI Platform Unit, Big Data Lab (BDL), Institute of Deep Learning (IDL), Silicon Valley AI Lab (SVAIL), and two new labs established this year, the Business Intelligence Lab (BIL) and the Robotics and Autonomous Driving Lab (RAL).

Baidu has put major emphasis on its Apollo open source platform for autonomous and connected vehicles and has partnered with dozens of Chinese and foreign firms in the auto sector. The platform components include the Apollo Open Software Stack and reference hardware and vehicle platforms, forming a relatively complete development package. At the Consumer Electronics Show (CES) in January, Baidu unveiled Apollo 2.0, which now includes a full security system to allow secure updates over the air. The company branding for Apollo cites the firm's growing AI personnel and capabilities in Beijing, Shanghai, Shenzhen, Silicon Valley, and Seattle. Baidu has also partnered with a leading Singaporean firm to boost Apollo use in Singapore, where autonomous vehicle development and testing is well underway. Baidu hopes Apollo will become like the Android OS of smart vehicles. Other Chinese private sector AI firms are already well down this path: Megvii's Face++ platform has 300,000 developers in 150 countries, according to the company.

The venture capital world in China and Silicon Valley has poured money into Chinese AI startups, with the volume of deals ramping up in early 2017 and continuing throughout last year. CB Insights estimates that China was the recipient of 48 percent of equity fund investments in AI in 2017, compared to 38 percent for the United States. There are now at least 30 Chinese AI startups which have received at least RMB 100 million (USD $15.8 million), and they cover a range of AI applications, from facial and voice recognition to natural language processing, and from AI-powered robotics and drones to financial applications and niche AI semiconductors.

The ramp-up in investment in China's AI sector has been driven by, in order of importance:

1. China's major Internet conglomerates that determined the vast amounts of data they held could be leveraged using AI to solve practical operational challenges and drive new business models (e.g. Baidu, Alibaba, and Tencent);
2. Technically savvy and largely internationally educated entrepreneurs with compelling technologies seeing opportunities to bring niche AI applications to a broader market and attracting funding (e.g. iFlytek, Megvii, SenseTime, and Horizon Robotics);
3. A wave of new and hard-working entrepreneurs hoping to jump on the AI train that have drawn investment both from the big players and Chinese and western VC firms in emerging areas such as autonomous vehicles, drones, ICs, and big data applications in finance and healthcare (e.g. CloudMinds, iCarbonX, Bitmain, and DJI); and

4. Spinoffs from Chinese government research institutions following some liberalization of rules governing intellectual property (e.g. Cambricon and Cloudwalk).

This growth has also been fueled by the perception that, outside of the United States, China currently represents the best overall ecosystem available globally for AI development, including the availability of technical and engineering talent (and increasing numbers with AI-specific capabilities), supportive government policies, willingness to adopt new technologies, and a vibrant startup community.

IV. Pursuing Indigenous Basic Research and Innovation in AI-Related Core Technologies

NDRC, MOST, and MIIT have all put emphasis on China developing the underlying technology architecture, basic academic theory, and systems to support major AI applications such as machine vision and autonomous vehicles. Since the AIDP was released in July, officials have moved to create new programs and re-adjust existing funds to align with the technological development goals outlined in the plan. To date, these efforts have been primarily focused on research in both basic theory and architecture of AI-related algorithms and techniques, AI-specific semiconductors, in addition to human talent development.

The AIDP puts a high level of focus on helping Chinese become leaders in basic theory and academic research in AI-related fields. Senior leaders at MIIT, NDRC, and MOST seem to understand that the key to AI leadership is not only access to data, but also being at the forefront of research into AI-related algorithms and techniques—an area where Chinese researchers continue to significantly lag leading companies and institutions in the United States. As a whole, China is at a distinct disadvantage on basic research, having had a late start, and having less than a dozen universities with advanced AI programs, compared to many dozens in the United States. Finding sufficient numbers of qualified AI faculty remains a huge challenge.

Responding to this problem and following the signals in the AIDP, China's government agencies responsible for coordinating university and research institute efforts have been creating and re-adjusting programs to emphasize AI-related programs. For example, MOST's "digital healthcare equipment" core national R&D program allocates upwards of $100 million in new funding for "AI-enabled" medical devices, including MRI image pattern

recognition based on neural networks, and an AI-based patient diagnosis system, similar to IBM's Watson. In MOST's intelligent robotics core R&D program, its most recent 2017 funding guidelines call for research in AI theory and algorithms to support machine learning and robotics tools. This includes the development of AI algorithms to be embedded in "cobots" (collaborative robots) and other robotic tools for traditional manufacturing industries that use vision-based AI analysis.

In addition, China's National Science Foundation early this year released guidelines for millions in basic AI research for Chinese universities. Many of the 2018 projects are aimed at basic AI research and other related areas such as quantum computing. For a full list, see here. More broadly, leading universities also appear to be gearing up for AI-related efforts, including via the increasingly active CAAI, which coordinates collaborative research efforts across academia in China and currently has 44 branches, including 37 professional committees and 7 working committees, covering the field of intelligent science and technology.

For some time prior to the AIDP debut, Chinese academics and company leaders had been increasingly active in leading AI conferences, contributing large numbers of papers to proceedings at international gatherings such as the Neural Information Processing Systems (NIPS). Leading AI players Baidu, Tencent AI Lab, JD.com, Didi Chuxing, Alibaba, Huawei, Qihoo360, and Toutiao are sponsors, and Chinese academics—often in collaboration with international academic and industry researchers—are well represented among the 20 percent or so of papers accepted. Among China's leading academic institutions, Tsinghua University (which reputedly has China's strongest scientific research capacity on AI) had a total of 6 papers accepted, and Peking University had four. In addition, many colleges and universities, including the Chinese Academy of Sciences, the University of Science and Technology of China, the Hong Kong University of Science and Technology, the Chinese University of Hong Kong, and the City University of Hong Kong, have produced articles published via NIPS. China's leading AI firms are also major contributors to conferences organized by the the AAAI (Association for the Advancement of Artificial Intelligence). Given Chinese government funding has just been recently increased for AI-related research, Chinese participation in these conferences and, more importantly, contribution to basic AI related theory and science is likely only to increase.

V. Semiconductors: Attempting to Chart a Different Course

In addition to the emphasis on research and education, the Chinese government is focusing major efforts on beefing up domestic capabilities in key hardware technologies underlying the AI stack. Government documents and statements have pointed to the need for China to develop its own AI semiconductor or "chip" capabilities in key AI-relevant categories such as neural network processors, graphics processors, and special-purpose reprogrammable chips, or FPGAs.

Upon a cursory analysis of China's AI chip landscape, there appears to be some promise. Chinese firms are developing and fielding some innovative solutions for "edge AI" chips that process less power-intensive operations such as simple voice or image recognition tasks and are embedded in consumer electronics. There are now roughly a dozen Chinese chip startups designing all sorts of these AI chip solutions for the Chinese consumer electronics market, but not fabricating the chips themselves (otherwise known as "fabless" firms). One example is Cambricon, a leading Chinese AI chip intellectual property (IP) developer, which is a spinoff from the Chinese Academy of Sciences and has licensed its IP to Huawei for an AI coprocessor (embedded within the Kirin 970 system on chip, or SoC) in its latest handset assist with image recognition tasks.

Yet for all the hype in the media, a deeper analysis reveals that China still remains a significant laggard to global chip leaders related to core AI applications, which demand massive chipsets with billions of transistors designed and fabricated on leading edge semiconductor process technology. As it currently stands, AI applications run by major Chinese tech firms are powered by foreign chips. For example:

- **Graphics Processing Units (GPUs):** China has produced no serious international competitor or even near-peer firm in the area of GPUs, which are currently widely deployed by firms for AI applications (especially for AI training networks). Jingjia Microelectronics, the one Chinese GPU firm that received an investment from China's National Integrated Circuits Industry Investment Fund (the "IC Fund"), the flagship government subsidy program, is developing older chip technology for the PLA that is roughly at least 10 years behind leading-edge GPU products. Chinese-backed investment group Canyon Bridge is in the process of acquiring U.K.-based GPU designer Imagination Technologies, yet their chips are more

oriented toward consumer-facing, low-power applications (similar to Cambricon's technology in the Huawei handset).

- **Microprocessors:** China currently has no domestic microprocessor firm that can match the power and performance of leading AI-capable microprocessor chipsets from foreign producers. Some government-backed domestic efforts are underway in this space (e.g. Longsun, Tianjin Phytium, Shanghai Zhaoxin, and Shenwei), but their technology is still significantly behind global standards and will likely remain so for a significant period of time.
- **Field-Programmable Gate Array (FPGAs):** Only a limited number of Chinese firms are producing FPGA chips (e.g. Shenzhen Pango Microsystems and Gowin Semiconductor), and their technology is roughly a decade behind global industry leaders. Earlier Chinese efforts to acquire U.S.-based FGPA producer Lattice Semiconductor were blocked by a U.S. government body that reviews foreign investments for national security implications.

While some would assume the Chinese government would be making efforts to close the gap with western chip makers in CPU, GPU, and FPGA technology, so far no serious effort is underway to do so—at least compared with the herculean efforts China is making to develop its domestic memory chip and foundry manufacturing industry, both comparatively mature technologies, where investment exceeds $40 billion. While MOST has launched several laboratory projects to develop small-scale GPU chips, these will likely be difficult to commercialize given their academic and government origins. While for these it will likely be hard to find broader market demand, they could still be used in some niche state-influenced application areas and scale up over time. China's flagship national IC Fund has not made a single investment into a Chinese FPGA or CPU company, and, as noted above, its only investment into the GPU space is questionable.

Recognizing this insurmountable foreign lead in proven commercial AI chip technologies currently in the market (GPUs, CPUs, and FPGAs), both Chinese entrepreneurs and government planners are placing some of their bets on alternative or emerging technologies that may help China "make a sharp turn to overtake" (弯道超车) foreign semiconductor firms. This is not just a Chinese strategy, as many industry experts believe that the most efficient chips for AI applications are those that are completely re-designed specifically for these new applications (e.g. the Google Tensor Processing Unit), and Chinese actors are keen to move in this direction.

In terms of government objectives, MOST, for example, issued a call for progress on new types of neural network processors in October, in a document entitled "Notice of the Ministry of Science and Technology on Issuing the Key Special Projects for Key Scientific Issues of Transformative Technology for 2017 in the State Key Research and Development Program." In addition an NDRC document on AI projects in November called for the development of a specific type of new AI chip—deep neural network processors—designed to directly compete with foreign GPU makers.

On the Chinese industry front, fabless Chinese firms Cambricon and Bitmain are apparently investing in R&D efforts to design AI processors aimed at higher-end applications beyond simple vision and voice recognition, targeting more complicated tasks such as in science modeling and autonomous vehicles. While details are sparse and products are not yet on the market, Cambricon is reportedly working with Chinese state-owned, second-tier server maker Sugon to use its IP in some sort of neural processing unit or an application-specific integrated circuit (ASIC) for AI applications. Cambricon further claims it is working on higher-end solutions for autonomous vehicles, but it has not announced any commercial partners. Bitmain, which has become well-known as a cryptocurrency mining ASIC design house, is working to develop an AI processor they call the "Sophon" (in a reference to the Chinese science fiction trilogy by Liu Cixin) for AI learning applications, although they have yet to indicate which if any partners they have for the chip. Several Chinese university research teams are also working on neuromorphic chips, or chips that mimic the architecture of the human brain, along with "qubits," the chips used within experimental quantum computing systems.

Notably absent, from these Chinese AI chip efforts are any leading Chinese original equipment manufacturers (OEMs) or internet companies—let alone have any global vendors signed up to actually use these domestic chips—indicating that these are still very much experimental and have a long, long way to go before reaching real commercial adoption. Although it may appear that China is able to exploit a rapidly expanding market with no clear winner, foreign firms again have a relative head start and several significant advantages. U.S. chip companies in particular have comparatively well-funded and advanced R&D efforts in neuromorphic chips (some developed in partnership with DARPA). Many foreign chip firms are beginning to bring to market special purpose AI chips that use alternatives to GPUs, taking advantage of unique new chip architectures, and have signed up major commercial partners such as Facebook for these new chip technologies. So while the Chinese government and its Chinese chip firms may announce ambitious goals, targets,

and even completed chip designs, they still lag significantly behind global firms in terms of meaningful traction in the commercial market.

Finally, Chinese chip firms are still massively outgunned by foreign firms in R&D spending—historically the winning factor in the chip technology race. For example, no Chinese company is among the top 10 firms who invest in semiconductor R&D—a group that together spent a total of $35.9 billion on R&D in 2017. This does not bode well for smaller-spending Chinese AI chip startups, and the Chinese government appears for now more interested in opening up its coffers to boost domestic semiconductor production in mature chip technologies, rather than directing its resources toward large-scale advanced chip R&D.

VI. Looking Ahead: Where Will the AIDP Matter Most?

The Chinese government is aggressively moving to cement China as a global leader in AI development and deployment. As it stands China has the most ambitious and well-funded government initiatives among nations that have identified AI as a priority. For China, this level of government organization and initiative seems logical, for as this paper details, China lags behind the United States and other countries in areas of key AI-related academic research and core technology. Thus it is not surprising to see China's early efforts to implement the AIDP focused on these gaps, which are related to: R&D, talent, directing government procurement to support national champions, standards, and regulation.

Ambitious government plans and policy targets will not necessarily lead to meaningful commercial outcomes that will drive Chinese industry ahead of their global peers. The payoff on government investments in talent, R&D, infrastructure, housing, etc., will take some time to yield tangible results. Aspirations for improvements in AI education outlined in the plan have been slow to get off the ground, and most Chinese universities outside the top 10 will continue to lack sufficiently trained faculty to offer advanced AI training. Where will the AIDP matter the most in the short term? We offer a few insights below:

A. R&D

Chinese planners are keen to direct their government resources to the development of core AI-related technologies and underlying theory. So far, a limited number of existing government R&D programs for robotics, medical devices, and ICT have been re-directed for

AI-related priorities. Moving forward, it will be critical to see whether entirely new R&D programs are stood up. For example, in the past China has created new "national R&D megaprojects" for major national priorities such as large civilian aircraft, jet engines, and telecom equipment. If China follows this trend and establishes a new megaproject for AI, that could quickly increase government R&D support in the field. In addition, it will be important to watch whether China's National IC Fund begins to make new and significant investments into Chinese AI chip firms, which could signal strategic alignment between China's semiconductor and AI planners.

Yet even if new government programs are established, it will take some time for their efforts to bear fruit. In the meantime R&D efforts by Chinese companies will have a more direct impact on China's overall AI capabilities. On average, Chinese firms invest less in R&D as a percentage of their revenue than their global peers, yet signs are that this is starting to change. For example, Baidu has announced that its Apollo program will see a $1.5 billion boost in R&D spending over the next three years. It is very likely that combined R&D spending in AI by Chinese companies exceeds that of the Chinese government, but the government does not publish total research funding numbers for AI, so we can only estimate. For the time being, future Chinese innovations in core AI related technologies will continue to be driven by Chinese industry, not the government.

B. Talent

In 2018 there will be focus on improving the educational ecosystem for AI in China, within universities and in other places—competition for AI talent with industry will remain a challenge in retaining qualified faculty and expanding AI programs beyond the top schools.

In the meantime, the private sector is not waiting around, and is pursuing new initiatives designed to generate more AI expertise. In addition to siting new AI labs in the United States and recruiting from U.S. universities and companies, big Chinese AI players are looking for other ways to grow the talent pool. **Alibaba** has already started part of what is planned as a $15 billion investment in the DAMO Academy (Discovery, Adventure, Momentum, Outlook) that will have a heavy AI focus and be headed by CTO Jeff Zhang. The initiative will consist of labs in seven cities in major high-tech zones including Hangzhou, Beijing, Singapore, Moscow, Tel Aviv, Silicon Valley, and the Seattle area. The collaborative effort will include University of California Berkeley's RISE Lab, and major U.S. universities including MIT, Princeton, and Harvard join Peking University, Zhejiang University, and

others on the advisory board. Machine learning, imaging processing, natural language processing, and quantum computing will all be in the mix.

In addition, recognizing that much of the world's AI expertise lies within the private sector and seeking innovative solutions to the lack of trained faculty, China's Ministry of Education (MOE) in February launched an AI talent training program for Chinese university teachers and students. The initiative is to be jointly sponsored by the MOE, the AI venture capital firm Sinovation, and Peking University.

C. Prioritizing applications and projects

Leading Chinese AI companies, with government encouragement, will continue to pursue projects aimed at solving real world problems, from medical imaging for cancer and disease diagnosis to smart city applications leveraging AI. Sinovation's Kai-fu Lee has termed this "techno-utilitarianism." This is where the successes and failures of China's AI sector will be most rapidly realized, and some successes in 2018 will be critical to keeping the private sector investment hose for AI companies clear and flowing. U.S. venture capital firms have a long history of investing in advanced technologies and tolerating failures, and it remains to be seen whether China's VC community will continue to favor AI investments over the next three to five years, particularly as some once-promising startups inevitably fall by the wayside.

Government funding via NDRC, MOST, and MIIT AI initiatives will continue to fuel aspects of AI development in government priority areas in 2018. For example, the NDRC 2018 Key Project Support List for Internet+, AI Innovative Development, and the Digital Economy includes 14 new projects, including Alibaba Cloud's City Brain Project and projects from smaller players including iFlytek, service robot maker UBTECH, and an AI chip from computer vision startup Hikvision. Reflecting to some degree government priorities, six of the 14 AI projects involve facial or voice recognition, or computer vision. (See Figure 3.)

Figure 3: Key Projects in AI for NDRC Support

Company	*Project*
Beijing Jingdong (JD) Shangke Information Technology Co., Ltd.	Construction of Open Source Platform for Deep Learning and Applications Project
Dawning (Sugon) Information Industry Co., Ltd.	Construction of Open Source Platform for Deep Learning and Applications Project
Shanghai Cambricon Information Technology Co., Ltd.	Cloud Deep Learning Processor Chip Industrialization Project

Suzhou Aispeech Information Technology Co., Ltd.	High-Performance Customizable Intelligent Voice Interactive Service Platform Industrialization Project
Hangzhou Hikvision Digital Technology Co., Ltd.	Computer Vision Artificial Intelligence Chip R&D and Industrialization Project
iFlytek Information Technology Co., Ltd.	High-Sensitivity Voice Recognition System Industrialization and Application Project
Synthesis Electronic Technology Co., Ltd.	Intelligent Service Robot Research and Development and Industrialization Project
Guangzhou Cloudwalk Information Technology Co., Ltd.	High-Precision Facial Recognition System Industrialization and Application Project
Sichuan Wisesoft Software Co., Ltd.	Industrialization and Application of Ultra High Accuracy Facial Recognition System Based on 3D Face Database
Shenzhen DJI Innovation Technology Co., Ltd.	Highly Reliable Unmanned Aircraft Product Industrialization Project
UBTECH	High-End Intelligent Service Robot Product Industrialization Project
Beijing Zhongdun Security Technology Development Company	High-Precision Facial Recognition System Industrialization and Application Project
Beijing Didi Infinite Technology Development Co., Ltd.	Didi Big Brain-based Urban Intelligent Traffic Management and Shared Travel Demonstration Project
Aliyun Computing Co., Ltd.	Urban Data Brain Project

Source: NDRC

As is evident from the NDRC project list, separating out commercial from government priorities is not straightforward. The MOST, NDRC, and MIIT program calls and action plans all cover similar ground and emphasize AI sectors and applications that have already been priorities among the major players and the target of intense development efforts by smaller established players and niche startups such as iFlytek, Aispeech, Megvii (Face++), Sensetime, and Geek+. The levels of funding that companies designated under the NDRC project support list can draw on remains unclear, and Alibaba Cloud, for example, would almost certainly be investing in smart city technology even without government support. NDRC funding could help smaller players with limited R&D budgets, but most of the companies being targeted for NDRC support appear to have ample funding from the venture capital community, which over the past year has increasingly focused on AI startups and even more mature companies that have reclassified themselves as AI firms.

The real government boost for the AI sector is likely to come on the procurement side, when things like smart city development really begin to take off, and Alibaba's City Brain project begins to yield practical results to apply to solving big city problems. Companies like Alibaba, Tencent, and Baidu, with clear goals for their AI application development projects, can count on a certain amount of support from city governments when municipalities start deploying pieces of the smart city architectures that central authorities have been touting

as critical to enhancing "governance capability." These efforts are likely to begin ticking up significantly in 2018, and already appear to have had some marketing success, with the announcement in late January that Alibaba's City Brain applications would be part of Malaysia's smart city development.

D. Regulating AI and setting standards

Finally, the AIDP calls for China to lead in the regulatory arena surrounding AI, and in setting international standards for AI-related technologies and applications. In January, the Standards Administration of China (SAC) released a white paper on AI standards, which it plans to present in Beijing in April at the first meeting of a new International Standards Organization (ISO) body, SC42. The document lays out some of the challenges facing standards work on AI, including the lack of a "top-level design" and the fragmented way AI-related technologies and applications are handled within the Chinese system and in the international community. In January the National Standardization Management Committee approved the establishment of the **National Artificial Intelligence Standardization Group and the Expert Advisory Group**, which will assist organizations such as the Chinese Electronics Standards Institute (CESI) and its AI working group, in the standards development process. Reflecting again the heavy role of the private sector in the process, the standards white paper drafters were drawn primarily from commercial AI companies. (See Figure 4.)

Figure 4: Companies/organizations authoring China AI Standards White Paper

Research Organizations	
China Electronics Standardization Institute	中国电子技术标准化研究院
CAS, Institute of Automation	中国科学院自动化研究所
CAS, Institute of Computing Technology	中国科学院计算技术研究所
Universities	
Beijing Institute of Technology	北京理工大学
Tsinghua University	清华大学
Peking University	北京大学
Renmin University	中国人民大学
Beijing University of Aeronautics and Astronautics (BUAA)	北京航空航天大学
State-Owned Enterprise	
China Telecom Corporation	中国电信集团公司
Private Sector	
iFlytek	科大讯飞股份有限公司
Huawei Technologies Co., Ltd	华为技术有限公司
Ali Coud Computing Co., Ltd	阿里云计算有限公司
Tencent Internet Plus (Shenzhen) Co., Ltd.	腾讯互联网加（深圳）有限公司

Alibaba Network Technology Co., Ltd.	阿里巴巴网络技术有限公司
Shanghai Computer Software Technology Development Center	上海计算机软件技术开发中心
Shanghai Zhizhen Intelligent Network Technology Co., Ltd.	上海智臻智能网络科技股份有限公司
Beijing iQiyi Technology Co., Ltd.	北京爱奇艺科技有限公司
Beijing Yousheng Zhikang Technology Co., Ltd.	北京有生志广科技有限公司
Jixianyuan (Beijing) Intelligent Technology Co., Ltd.	极限元（北京）智能科技股份有限公司
Beijing Toutiao Technology Co., Ltd.	北京字节跳动科技有限公司（今日头条）
Beijing Sensetime Technology Development Co., Ltd.	北京商汤科技开发有限公司
Zhejiang Ant Micro Financial Services Group Co., Ltd.	浙江蚂蚁小微金融服务集团有限公司
Baidu Network Technology Co., Ltd.	百度网络技术有限公司
Chongqing Kaiser Technology Co., Ltd.	重庆凯泽科技股份有限公司
Haier Institute of Industrial Intelligence Co., Ltd	海尔工业智能研究院有限公司
Chongqing Cloudwalk Technology Co., Ltd.	重庆中科云丛科技有限公司
Beijing Deep Glint Information Technology Co., Ltd	北京格灵深瞳信息技术有限公司
Foreign Companies	
International Business Machines (China) Co., Ltd.	国际商业机器（中国）有限公司
Intel (China) Co., Ltd.	英特尔（中国）有限公司
Matsushita Electric (China) Co., Ltd.	松下电器（中国）有限公司

Source: Standardization Administration of China (SAC)

Issues surrounding the collection of user information, data protection, data privacy, and cross-border data flows are also likely to have an impact in China's AI sector in 2018. If the Chinese government imposes stricter data localization requirements in implementing its new Cybersecurity Law, this could hurt AI research efforts involving multinational firms operating AI labs in China by hampering their ability to seamlessly transfer data sets across borders. China's emerging data regime and concerns over data privacy and government surveillance will pose major new challenges for China's large AI companies as they expand globally. Alibaba and Tencent have pledged to meet the requirements of the EU General Data Protection Regulation (GDPR), set to take effect May 25, but it remains unclear how far along they are and how EU regulators will view these efforts. EU regulators will be increasingly focusing on large Chinese platforms and how they handle data. So far, it appears that no major Chinese AI firm is leveraging data sets to train AI algorithms that contain data sets that contain data related to EU citizens, according to discussions with Chinese government and company officials.

E. Will China's government and private sector drive a leading effort?

The Chinese government's AIDP landed at a time when major Chinese companies were already staking significant parts of their future on AI-based applications both familiar and frontier. The plan and related discussions have identified real gaps in Chinese ability to

domestically develop world-leading AI technology, and the government seems motivated to close those gaps where the private sector might not on its own. As the foregoing analysis has shown, the government's mobilization appears great in scale but uncertain in result. Initial efforts and the rapidly developing private sector will provide analysts with numerous micro-level metrics of success in the wide array of technologies categorized as AI. Moving forward, Chinese companies and governments will deploy AI technologies in novel ways that will have significant consequences in a number of economic sectors and in governance. When it comes to global leadership, however, it will be crucial to maintain focus on the underlying technologies and the human resources. Though significant gaps remain, China's development will not occur in isolation but in cooperation and competition with global counterparts. Whether or not the AIDP's goal of Chinese leadership is realized, Chinese AI efforts merit close continued attention.

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