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China's Smart Cities Development

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Acronyms

Acronym	Full Name
3GPP	3rd Generation Partnership Project
ADB	Asian Development Bank
AI	artificial intelligence
AMI	advanced metering infrastructure
ARIA	Asia Reassurance Initiative Act
ASEAN	Association of Southeast Asian Nations
BUILD	Better Utilization of Investments Leading to Development
BRI	Belt and Road Initiative
CAC	Cybersecurity Administration of China
CAICT	China Academy of Information and Communications Technology
CASC	China Aerospace Science and Technology Corporation Limited
CASIC	China Aerospace Science and Industry Corporation
CCID	China Electronic Information Industry Development
CCP	Chinese Communist Party
CCTV	closed-circuit television
CEC	China Electronics Corporation
CEIEC	China National Electronics Import & Export Corporation
CETC	China Electronics Technology Group Co., Ltd.
CIP	Division for International Communications and Information Policy, U.S. Department of State
CISA	Cybersecurity and Infrastructure Security Agency, U.S. Department of Homeland Security
CNNVD	Chinese National Vulnerability Database
CRBC	China Road and Bridge Corporation
CRRC	China Railway Rolling Stock Corporation
CVE	Common Vulnerabilities and Exposures
DFC	U.S. International Development Finance Corporation
DHS	U.S. Department of Homeland Security
DOD	U.S. Department of Defense
DVR	digital video recorder
EU	European Union
FCC	Federal Communications Commission
FDI	foreign direct investment
FYP	Five Year Plan
GB/T	voluntary national standard
GCTC	Global City Teams Challenge
GIS	Geographic Information Systems
GPS	Global Positioning Systems
HCSEC	Huawei Cyber Security Evaluation Centre
ICS	industrial control systems
ICT	information and communications technology
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IGF	Internet Governance Forum
IoT	Internet of Things
IP	internet protocol
ISO	International Organization for Standardization
IT	information technology
ITA	U.S. International Trade Administration
ITAN	Infrastructure Transaction and Assistance Network
ITS	intelligent transportation systems
ITU	International Telecommunication Union

JTC	Joint Technical Commission
LTE	long-term evolution
MIIT	China's Ministry of Industry and Information Technology
MIT	Massachusetts Institute of Technology
MOHURD	Ministry of Housing and Urban-Rural Development
MOST	China's Ministry of Science and Technology
MOT	China's Ministry of Transportation
MoU	Memorandum of Understanding
MPS	China's Ministry of Public Security
MSS	China's Ministry of State Security
NB-IoT	Narrowband Internet of Things
NDRC	China's National Development and Reform Commission
NIST	U.S. National Institute of Standards and Technology
NSF	National Science Foundation
NUP	National New-type Urbanization Plan 2014-2020
NVR	network video recorder
OBD	on-board diagnostics
OPIC	U.S. Overseas Private Investment Corporation
PCAST	President's Council of Advisors on Science and Technology
PLA	People's Liberation Army
PPP	public-private partnership
PRC	People's Republic of China
R&D	research and development
RFID	radio frequency identification
RMB	*renminbi*
RS	remote sensing
SAC	Standardization Administration of China
SEZ	special economic zone
TTP	tactics, techniques, and procedures
UK	United Kingdom
UN	United Nations

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Executive Summary and Key Findings

Around the world, countries and cities chasing improved resource allocation, increased efficiency, enhanced public safety, and sustainable growth are turning to a range of networked technologies to help manage everything from government services to traffic patterns. The collective term for these technology solutions has become "smart cities," first coined in the 1990s but re-introduced with its current meaning by IBM in 2008. Smart cities can refer to an entire urban ecosystem employing smart cities principles or to the constituent technologies and applications that make up that ecosystem. While there is no standard list of "smart cities" technologies and applications, at its core, the term signifies the use of digital technology to collect and share data about municipal operations that had been previously unavailable or disaggregated, allowing for improved municipal management and services. Successful development and deployment of smart cities technologies is likely to have major social and economic impacts as massive amounts of data are collected and used to improve efficiency in daily life and optimize or automate previously burdensome or inefficient governance tasks.

China has become a global leader in smart cities initiatives, combining embedded sensors, metering devices, cameras, and other monitoring technologies with big data processing and artificial intelligence (AI) analysis to help manage its cities and public spaces. Its leadership has clearly signaled the importance of smart cities development, elevating it to a national strategy, and has poured government resources into furthering its growth. China reportedly has nearly 800 smart cities pilot programs underway or in planning, which would be more than half of the total smart cities around the world. As China's state-run news service Xinhua recently editorialized, China believes it will win "the global race toward building an intelligent and data-driven society."

While the improvement of municipal infrastructure is ostensibly benign, the pace, scale, and application of China's smart cities development poses new and substantive challenges to U.S. interests at home and abroad. U.S. support for global smart cities development is tied to broader foreign policy initiatives intended to bolster support for a values-led system and offer an alternative to authoritarian development models. While the United States is itself a world leader in developing smart cities technologies, its sustained position is by no means guaranteed, particularly given how aggressively and successfully China has advanced in these areas.

Moreover, how countries use the data that smart cities platforms collect is a concern. Technologies that by definition capture and synthesize massive amounts of real-world, real-time data on people's daily lives can easily be deployed in a manner that threatens personal privacy or even national security. This is a concern for the United States and other countries considering the risks of including Chinese technologies in their critical infrastructure. China is actively promoting its smart cities solutions abroad via the Belt and Road Initiative's technology engagement policies, making a thorough understanding of these potential risks especially timely.

This report seeks to answer the following research questions. First, it focuses on the policies the Chinese government has enacted to promote smart cities and China's progress in implementing smart cities and key enabling technologies, particularly with respect to mass surveillance. Second, the report describes China's efforts to promote its smart cities technologies abroad and the potential impact of this promotion. Finally, the report compares the state of smart cities development in China and the United States, identifies potential risks to and vulnerabilities in U.S. critical infrastructure stemming from the use of Chinese products, and describes the implications of China's smart cities development for U.S. national security and global competitiveness.

The research for this report relied on Chinese and English language sources, including government announcements, academic papers, news items, and industry reports.

Key Findings

In order to better inform the U.S. government and Congress as they assess how to secure U.S. economic and security interests *vis-à-vis* Chinese smart cities plans, this report identifies a number of key findings:

Chinese Smart Cities Policies

- Smart cities are part of a decades-long pattern of Chinese government programs that seek to digitize and "informatize" cities to improve China's comprehensive national power and internal strength.
- The central government's top-down approach to smart cities pilot programs and shift away from city-led initiatives has led to the centralization of decision-making and the decentralization of implementation. This has resulted in a nonlinear and unpredictable development trajectory for Chinese smart cities that allows for course-correction and experimentation.
- Chinese smart cities policies have begun to coalesce and standardize after an initial period of experimentation and bureaucratic overlap.

Chinese Smart Cities Development Trends

- The development of Chinese smart cities technology is primarily top-down, driven by government investment, and generally aligns with regional development patterns—with the bulk of projects located in China's more economically-developed eastern seaboard.
- Estimates of the size of the smart cities solutions market in China vary widely and their reliability is somewhat unclear; Chinese consulting firms bullishly pegged the market at RMB 7.9 trillion ($1.1 trillion)[1] in 2018 and projected a 33 percent compound annual growth rate between 2018 and 2022.
- Chinese municipal authorities charged with smart cities development commonly cite transportation, public services, public safety, education, healthcare, and environmental protection as focus areas for Chinese smart cities projects.
- While there are numerous noted examples of the successful deployment of smart cities solutions in China, many challenges still exist, including long-term program sustainability, insufficient information-sharing mechanisms between governing authorities, and a dearth of accurate information about actual progress in smart city development funding and implementation. Together, these deficiencies hinder a more widespread embrace of smart cities across the country.

Chinese Surveillance

- Chinese government officials are embracing smart cities technologies—especially the Internet of Things (IoT), mobile internet, cloud computing, and big data—to expand, improve, and automate information collection and analysis for mass surveillance.

[1] The exchange rate used in the report is RMB 7.14798 for every $1.

- Much of the implementation of this "smart surveillance" occurs at the local level, although local surveillance programs are increasingly tapping into national-level information and network resources.
- Massive local implementation of smart cities surveillance has created difficulties in upgrading surveillance equipment and fostered a low degree of standardization and integration for systems deployed in different regions and localities in China.
- Even as China embraces smart cities technologies to surveil its people, it continues to use volunteers to monitor the actions of the general population and to augment smart city surveillance. This practice of "mass defense, mass rule" (群防群治) is a continuation of historical Chinese Communist Party (CCP) surveillance efforts that stands to benefit greatly from increased use of smart cities technologies.
- China's current mass surveillance efforts and the industry that supports them are some of the largest and most prolific in the world, but China's future ambitions for domestic mass surveillance likely dwarf the size and scope of its current extensive surveillance state. The CCP's intent to deploy 626 million video cameras by 2020, widening adoption of artificial intelligence, and functionally nonexistent civil rights protections are laying the groundwork for a digital panopticon.

Chinese Promotion of Smart Cities Technologies Abroad

- Chinese technology companies have been successful in promoting and installing smart cities technologies around the world. Analysts identified 398 reported instances of 34 different Chinese firms exporting smart cities technologies through involvement in smart cities development projects in a total of 106 countries.
- The Belt and Road Initiative (BRI), China's signature foreign policy, highlights smart cities as a "strategic opportunity" for Chinese firms to expand abroad. While these plans do not include specifics about future expansion, it is likely that smart city promotion as part of the Belt and Road Initiative will continue to be an international priority with backing from the highest levels of the Chinese government.
- In developing nations, smart cities projects focused on installing surveillance technologies and network infrastructure have been notable successes of Chinese national champions like Huawei, often with the financial backing of state-owned banks like the Export-Import Bank of China.
- Chinese firms see more developed countries as valuable sources of technology and expertise as well as markets for Chinese technology, frequently developing partnerships and establishing joint laboratories in these countries. These partnerships are used in part to promote Chinese technology standards and expand access to advanced technology and in part to improve international perceptions of Chinese firms.
- Though clear information on data sharing arrangements between Chinese technology firms and local governments abroad could not be found, expanding access to global data sets to include these firms gives them a market advantage and may aid Chinese intelligence collection efforts.
- Through all of these avenues, the growth of Chinese smart cities exports presents a serious economic and security challenge to the United States.

Smart Cities in the Context of U.S.-China Relations

- The United States government has adopted a bottom-up approach to smart city development that stands in contrast to China's top-down model, taking a "convening" rather than a leading role and encouraging localized implementation, with a policy focus on security and privacy as "first order design principles."
- The United States has tied its promotion of smart cities abroad to larger policy initiatives under the Indo-Pacific strategy that emphasize a values-led system as an alternative to authoritarian development models (namely, China's BRI).
- Challenges in capturing and categorizing data make comparisons of U.S. and Chinese smart cities technologies difficult, but evidence suggests that Chinese hardware is broadly on par with U.S. products, while Chinese software lags behind U.S. offerings.
- What makes U.S. smart cities policies lasting and sustainable in the long run—the bottom-up approach that leverages local skills and advantages—also makes these communities vulnerable to compromised technologies in city infrastructure and systems, Chinese or otherwise, as the focus has historically been more on local priorities and needs than a unified, national approach to privacy and security.
- While the U.S. government has taken some steps to secure ICT systems and supply chains, Chinese smart cities products are still in use across the United States, despite known vulnerabilities and suspected potential for compromise through PRC legal mandates requiring Chinese firms to share information with their government.

Recommendations

On the basis of these key findings, the authors offer the following recommendations to ensure U.S. global competitiveness in overseas smart cities markets, safeguard U.S. national security interests at home and abroad, and protect the privacy of U.S. citizens:

1) **To better quantify the spread of foreign smart cities technologies in U.S. domestic systems, encourage the creation of local and regional oversight task forces to collect more accurate data, identify potential risks in foreign investment in domestic infrastructure, and maintain an information-sharing mechanism between these communities.**

One of the fundamental challenges identified in this report is the dearth of quantifiable knowledge regarding the scope and nature of new smart cities technologies and the possible risks increased global adoption of these technologies poses. The U.S. government must first characterize the inflow of foreign smart cities technologies, determining both volume and capabilities of smart cities products coming into the United States. Reports designated under U.S. Code Title 13 from the U.S. Census Bureau to Congress (in conjunction with the Bureau of Economic Analysis and U.S. Customs and Border Protection) could be modified to include specific reporting on smart cities technology imports, with these technologies prioritized according to U.S. national security concerns. The Bureau of Economic Analysis also reports on U.S. businesses with significant foreign investment, and these studies could be correlated with a list of U.S.-built smart cities technologies to capture the full range of potential security risk.

The Department of Commerce, potentially in partnership with the Department of Homeland Security's Cybersecurity and Infrastructure Security Agency (CISA), should work with state and local governments to establish a task force structure that includes input from stakeholders in

government, academia, and industry. The task force should produce annual reports on smart cities best practices and risks. Alternatively, Commerce could commission a National Academies effort to convene the task force.

This effort could be the first step in a process leading to some form of smart cities stimulus to develop and apply smart city technologies. Stimulus money run through the Department of Commerce's Economic Development Administration would be tied to city and regional adherence to best practices established by the task force reports, meeting local needs through the task force process and removing the requirement for overly prescriptive regulation of technologies. The results of the task force reports could also inform the international efforts of the State Department's Division for International Communications and Information Policy (CIP) (outlined in Recommendation 3).

2) **To mitigate the global spread of Chinese smart cities technologies, support U.S. competitiveness in international smart cities markets.**

To achieve this goal, the U.S. government should pursue a two-track approach. In the short term, it should continue investing resources and personnel to support U.S. businesses in key regions such as Southeast Asia and Africa to keep abreast of not only smart cities development trends, but also as an effort to outpace China in these markets. The State Department's Bureau of Economic and Business Affairs should initiate studies of specific smart cities trends in these key regions examining market and investment indices. Congress should also consider tax incentives to U.S. businesses investing in key smart cities technologies, possibly through adjustments to the Research and Experimentation Tax Credit, while the United States should incentivize nations in strategic regions to invest in U.S.-produced technologies, potentially with loan guarantees through the U.S. International Development Finance Corporation, the U.S. Export-Import Bank, or in coordination with treaty allies such as Japan and South Korea that are already investing in smart cities technologies for developing nations.

In the long term, Washington should study demographic trends and identify future cities and regions likely to invest in smart cities technologies, particularly as China works to overcome issues of market access. The Department of Commerce should initiate a series of workshops or roundtables with key U.S. tech sector companies, researchers, and other stakeholders (such as from the Institute of Electrical and Electronics Engineers (IEEE)) to determine what policies and information would be most useful for the U.S. private sector to compete in international smart cities technologies markets. The meetings should also involve Department of Defense and Department of Homeland Security personnel to highlight U.S. policy and best practices regarding the national security implications of the rising influence of Chinese smart cities technology companies and could incorporate reporting from the task force discussed in Recommendation 1.

3) **Support U.S. participation in standard-setting and smart cities technology adoption abroad.**

The United States and its allies can leverage comparative advantages in smart cities technologies, providing more attractive options to consumers while allowing for economies of scale and promotion of shared values. To this end, the CIP should increase engagement with U.N. and international standards organizations such as the International Telecommunication Union (ITU), the Internet Governance Forum (IGF), and International Organization for Standardization (ISO) to ensure that the United States advocates for its interests and protects the adoption of high-quality standards. Domestically, the Department of Commerce's National Institute of Standards and

Timing (NIST), CIP, CISA, and other stakeholders should develop a specific smart cities program to coordinate efforts to influence standards, promote U.S. technologies, and disseminate best practices regarding safe city applications. Congress should continue support of the Better Utilization of Investments Leading to Development (BUILD) Act of 2018 that transforms the Overseas Private Investment Corporation (OPIC) into the U.S. International Development Finance Corporation (DFC), while the U.S. Export-Import Bank should continue its Smart Cities, Regions and Communities Export Initiative.[2]

4) **Prioritize Five Eyes countries, treaty allies, and countries with U.S. military bases to determine whether or not there are present vulnerabilities within these countries' government facilities and critical infrastructure stemming from the use of Chinese products.**

The United States should use existing intelligence-sharing channels and facilitate coordination with relevant trade counterparts to acquire data on security vulnerabilities arising from the use of smart cities technologies. The July 2018 meetings of Five Eyes representatives in Ottawa and Nova Scotia, Canada on the topic of 5G technologies and the potential threat posed by Huawei products could serve as a model for a broader discussion of Chinese smart cities technologies. That meeting also led to a coordinated strategy with trade and security partners such as Germany and Japan in responding to potential threats from Chinese 5G technologies, again presenting a model for future international strategies related to Chinese smart cities products and services. This international activity could be part of a coordinated effort that includes the domestic task force study discussed in Recommendation 1, first determining domestically the extent of security vulnerabilities and then using existing intelligence channels to share findings with partners and allies.

5) **Consider legislation that clearly outlines categories of critical infrastructure that should be more insulated from supply chain infiltration by nations with adversarial and aggressive intelligence collection priorities like China.**

This report finds that regardless of the actual degree of reliance upon Chinese smart city products in U.S. smart city applications, Chinese dominance of the supply chain for high-technology products suggest that the risk of supply chain infiltration will be nearly impossible to eliminate. Nevertheless, the United States should undertake measures to insulate certain types of critical smart city infrastructure from supply chain infiltration by Chinese companies, especially core telecommunications infrastructure, electrical power grid systems, and other categories that together make up the foundation of smart city development. Careful research and legislation could establish protected categories of smart city infrastructure to mitigate or lessen the risk of supply chain infiltration that could increase the number of viable and vulnerable attack surfaces available for exploitation by an adversary. There is already precedent in China for these types of measures, suggesting that some degree of reciprocity from the United States may be warranted: China's *Measures for the Protection of Information Security Levels*, also referred to as the *Multi-Level Protection Scheme*, prescribes categories of information and data management technology that are critical to national security and therefore cannot use foreign suppliers.

[2] "Smart Cities, Regions and Communities: Export Opportunities," International Trade Administration, Summer 2016, https://www.trade.gov/markets/smartcities.pdf.

Introduction

The term "smart cities," with its connotations of ultra-modern order and efficiency, has long existed as a conception of idealized urban planning.[3] Along with antecedent ideas like intelligent cities, digital cities, and wired cities, smart cities framed the thinking of individuals who wanted to bolster the entrepreneurial, political, and cultural capital of cities, using technology as a means to connect and empower people. It also inspired individuals who believed that technology could provide unprecedented, efficient control of urban utilities and services.[4] These early, abstract notions of smart cities fueled visions of metropolises transformed by technology and made markedly better in the eyes of political, economic, and cultural stakeholders.[5]

Technology advances have made it possible to begin making these nebulous conceptions of smart cities more concrete and have clarified shared understandings of what technologies and components should be considered part of smart cities. IBM has been particularly influential in this respect. The company introduced smart cities as a marketing initiative in 2008, arguing that the world's increasing trend towards urbanization created imperatives for technology-driven solutions to improve the livability and manageability of urban spaces.[6] The rise of cities, in both number and size, created challenges—in areas like pollution, public safety, energy, and transportation—that were likely to become increasingly severe.[7] Left unresolved, these problems could hinder the economic, political, and social capital that was uniquely concentrated in cities.

IBM helped advance the notion—especially in China—that data from a city's core operational systems could be integrated and shared over interconnected networks, allowing for more optimized responses to needs.[8] As one IBM report argued, "Technological advances mean that aspects of the operation and development that city managers have previously been unable to measure—and therefore unable to influence—are increasingly being digitized…With the greater digitization and

[3] Amy Glasmeier and Susan Christopherson, "Thinking About Smart Cities," *Cambridge Journal of Regions, Economy and Society* 8, 2015: 3-12, https://dusp.mit.edu/sites/dusp.mit.edu/files/attachments/publications/Smart%20Cities%20CJRES%20021415.pdf.

[4] Pablo Chamoso, Alfonso Gonzalez-Briones, Sara Rodriguez, and Juan M. Corchado, "Tendencies of Technologies and Platforms in Smart Cities: A State of the Art Review" *Wireless Communications and Mobile Computing*, 2018, accessed at https://www.hindawi.com/journals/wcmc/2018/3086854/; Rob Kitchin, "Making Sense of Smart Cities: Addressing Present Shortcomings," *Cambridge Journal of Regions, Economy and Society* 8, 2015: 131-136.

[5] Amy Glasmeier and Susan Christopherson, "Thinking About Smart Cities," *Cambridge Journal of Regions, Economy and Society* 8, 2015: 3-12, https://dusp.mit.edu/sites/dusp.mit.edu/files/attachments/publications/Smart%20Cities%20CJRES%20021415.pdf.

[6] Susanne Dirks and Mary Keeling, "A Vision of Smarter Cities," IBM Institute for Business Value, June 2009, https://www-03.ibm.com/press/attachments/IBV_Smarter_Cities_-_Final.pdf; Fan Yang and Jian Xu, "Privacy Concerns in China's Smart City Campaign: the Deficit of China's Cybersecurity Law," *Asia and the Pacific Policy Studies* 5, 2018: 533-543; Kelly Yang, Aideen Clery, and Domenico Di Lello, "Smart Cities in China," EU SME Centre, 2015: 1-34.

[7] Xu Qingrui 许庆瑞, Wu Zhiyan 吴志岩, and Chen Litian 陈力田, "[Smart Cities Framework and Vision] (智慧城市的愿景与架构)," *Journal of Industrial Engineering and Engineering Management* 管理工程学报 26, no. 4 (2012): 1-7.

[8] Shuwen Zhou, Samantha Anderson, Boshu Cui, and Shenglin Zhang, "Smart Cities and Social Governance: Guide for Participatory Indicator Development," United Nations Development Programme in China, 2017: 1-87.

interconnection of a city's core systems, the newly gained information can be used for intelligent and informed decision making."[9]

The precise definition of smart cities and the scope of technologies and applications that should be considered part of the concept continues to be a topic of debate, but the basic elements are relatively consistent.[10] Most definitions of smart cities focus on the technology-enabled acquisition, integration, analysis, and application of data from a city's core management systems, such as physical infrastructure, transportation infrastructure, or utility infrastructure. One of the simplest definitions for smart cities, derived from academic perspectives, is "the use of technology to facilitate the coordination of fragmented urban sub-systems."[11] Most other definitions are substantially more complex, such as the one used by China's first smart cities-focused investment fund, which states, "Smart cities refers to a system of systems of physical infrastructure, information infrastructure, social infrastructure, and commercial infrastructure, encompassing an area's population, transportation assets, energy resources, commercial activity, and communications, that are interconnected with the help of next generation information technologies like the Internet of Things, cloud computing, and decision-making optimization. Smart cities allow a city to implement rapid command and decision-making, real-time incident response, and coordinated operation of city services."[12]

- The acquisition of data in a smart cities system refers to the use of technology to collect and monitor data inputs from a broad range of infrastructure components. It involves turning the workings of these components (e.g., traffic flow, water quality, or the movement of people around a city) into measurable data points. Relevant technologies for these tasks include sensors, radio frequency identification (RFID), satellite positioning, card readers, and video capturing devices.[13]
- The transmission of data in a smart cities system refers to elements within the various core systems of a smart city that exchange data, regardless of location, supporting constant machine-to-person and machine-to-machine communication. This component can also include data storage. The technologies involved in these operations can include specialized

[9] Susanne Dirks and Mary Keeling, "A Vision of Smarter Cities," IBM Institute for Business Value, June 2009, https://www-03.ibm.com/press/attachments/IBV_Smarter_Cities_-_Final.pdf; Kelly Yang, Aideen Clery, and Domenico Di Lello, "Smart Cities in China," EU SME Centre, 2015: 1-34.

[10] Fan Yang and Jian Xu, "Privacy Concerns in China's Smart City Campaign: The Deficit of China's Cybersecurity Law," *Asia and the Pacific Policy Studies* 5, 2018: 533-543.

[11] Amy Glasmeier and Susan Christopherson, "Thinking About Smart Cities," *Cambridge Journal of Regions, Economy and Society* 8, 2015: 3-12.

[12] Harfor Fund Management Co., Ltd. 华富基金管理有限公司, "[Harfor Smart City Flexible Configuration Mixed Securities Investment Fund Prospectus] (华富智慧城市灵活配置混合型证券投资基金招募说明书)," 30 April 2019, http://static.cninfo.com.cn/finalpage/2019-06-15/1206359539.PDF.

[13] Li Lifeng 李立峰 and Fan Jituo 樊继拓, "[Xiong'an New District's "Smart Cities" Article: Smart on the Cloud] (雄安新区之"智慧城市"篇: 云上的智慧)," *Sinolink Securities* 国金证券, 21 August 2017; Antoine Bagula, Lorenzo Castelli, and Marco Zennaro, "On the Design of Smart Parking Networks in the Smart Cities: An Optimal Sensor Placement Model," *Sensors* 15, no. 7 (2015): 15443-15467; Kelly Yang, Aideen Clery, and Domenico Di Lello, "Smart Cities in China," EU SME Centre, 2015: 1-34; Susanne Dirks and Mary Keeling, "A Vision of Smarter Cities," IBM Institute for Business Value, June 2009, https://www-03.ibm.com/press/attachments/IBV_Smarter_Cities_-_Final.pdf.

video networks, wired and wireless networks (including 5G), cloud networks, and data centers.[14]

- Finally, the integration of data in a smart cities system refers to structuring and combining data inputs. Big data, which helps to organize incoming data, and artificial intelligence (AI), which helps to analyze and interpret data, are both critical technologies for this aspect of smart cities operations.

Once acquired, transmitted, and processed, smart cities data can be applied in any number of areas, creating unprecedented awareness of the movement, location, and condition of objects within a city. A representative sample of smart cities application areas is provided in Table 1.

Table 1: Potential Smart Cities Application Areas[15]

Application Area	Applications	Application Area	Applications
Energy	Smart streetlights	Mobility	Real-time public transit information
	Dynamic electricity pricing		Digital public transit payments
	Home energy automation systems		Autonomous vehicles
	Building automation systems		Predictive maintenance of transportation infrastructure
	Energy recycling		Smart parking
	Energy distribution automation systems		Intelligent traffic signals
Water	Water consumption tracking		Congestion pricing
	Leakage detection and control		Real-time road navigation
	Smart irrigation		Car sharing
	Water quality monitoring		Bike sharing
Security	Emergency response optimization		Traffic control and management
	Real-time crime mapping	Waste	Digital tracking and payment for waste disposal
	Facial recognition		Optimization of waste collection routes
	License plate recognition	Integrated Platforms	Emergency response systems
	Predictive policing		E-governance
	Smart surveillance		
	Early warning systems		
	Crowd management		

[14] Li Lifeng 李立峰 and Fan Jituo 樊继拓, "[Xiong'an New District's "Smart Cities" Article: Smart on the Cloud] (雄安新区之"智慧城市"篇: 云上的智慧)," *Sinolink Securities* 国金证券, 21 August 2017; Kelly Yang, Aideen Clery, and Domenico Di Lello, "Smart Cities in China," EU SME Centre, 2015: 1-34; Susanne Dirks and Mary Keeling, "A Vision of Smarter Cities", IBM Institute for Business Value, June 2009, https://www-03.ibm.com/press/attachments/IBV_Smarter_Cities_-_Final.pdf.

[15] Jonathan Woetzel, Jaana Remes, Brodie Boland, Katrina Lv, Suveer Sinha, Gernot Strube, John Means, Jonathan Law, Andrés Cadena, and Valerie von der Tann, "Smart Cities: Digital Solutions for a More Livable Future," McKinsey Global Institute, June 2018; Analysys Yiguan (Analysys 易观), "[2018 Analysis on Smart City Digitalization Development] (智慧城市数字化发展专题分析 2018)," 6 September 2018, 1-45; Li Lifeng 李立峰 and Fan Jituo 樊继拓, "[Xiong'an New District's "Smart Cities" Article: Smart on the Cloud] (雄安新区之"智慧城市"篇: 云上的智慧)," *Sinolink Securities* 国金证券, August 21, 2017.

The very broad range of technologies and applications that smart cities encompass ensures that a significant number of industries have interests in smart cities development. These include hardware manufacturing, software development, telecommunications, logistics and transportation, security services, environmental protection, health, cloud services, data analytics, mobile payments and financial technologies (fintech), AI, and the Internet of Things.[16]

Numerous countries have begun focusing on developing smart cities initiatives, and national investment in smart cities has expanded around the globe.[17] In particular, China has emerged as a global leader in smart cities initiatives. Its position has been fueled by leadership imperatives calling for primacy across an expansive range of cutting-edge technologies. The Chinese government has elevated smart cities to a "national strategy" (国家战略) and treats it as a cornerstone of China's future economic and urban development strategies.[18] In accordance with these priorities, the government has brought its preferred modes of industrial policy to bear on smart cities, leading to a steady output of government plans to steer the development of the industry and a flood of investment to encourage market entry and expansion. By June 2016, more than 500 municipalities across China had initiated or announced their intention to initiate smart cities pilot projects, accounting for nearly half of the smart cities locales active or under construction around the globe.[19] This demand signal has created a substantial market for smart cities products and services. Chinese industry analysts expect the size of China's smart cities market to exceed RMB 10 trillion in 2019 ($1.4 trillion), with projections that it will exceed RMB 18 trillion ($2.5 trillion) by 2021.[20] It is worth noting that these estimates are higher than non-Chinese assessments of the size of the entire global smart cities market, illustrating that there are definitional ambiguities that make it difficult to estimate the size of China's smart cities market relative to the rest of the world.[21]

As the world's second-largest economy and home to several of the world's largest cities, China's race towards full-scale implementation of smart cities technologies will have critical implications for its own population and the rest of the world. In five chapters, this report examines China's pursuit of smart cities technologies and their impact on U.S. economic and national security interests.

Chapter 1 outlines China's approach to smart cities development, describing the policy decrees and documents that underpin China's rapid embrace of smart cities. Chapter 2 describes the current

[16] Analysys Yiguan (Analysys 易观), "[2018 Analysis on Smart City Digitalization Development] (智慧城市数字化发展专题分析 2018)," September 6, 2018, 1-45.
[17] "Super Smart City: Happier Society with Higher Quality," Deloitte China, 2018: 4-6, https://www2.deloitte.com/content/dam/Deloitte/cn/Documents/public-sector/deloitte-cn-ps-super-smart-city-en-180629.pdf.
[18] Analysys Yiguan (Analysys 易观), "2018 Analysis on Smart City Digitalization Development" [智慧城市数字化发展专题分析 2018], 6 September 2018.
[19] Teamax Smart City Technology Co., Ltd., "[Teamax Smart City Technology Co., Ltd. 2018 Annual Report] (天夏智慧城市科技股份有限公司 2018 年年度报告全文)," June 2019: 1-199.
[20] Qiao Mai 乔麦, "[Tencent's 300 Million Shares of Shijiazhuang ChangShan BeiMing Technology Co., Ltd.: It's Actually for Countering Alibaba] (腾讯 3 亿入股常山北明:竟是为对抗阿里)," *China Fund News* , June 8, 2018, http://finance.sina.com.cn/stock/s/2018-06-08/doc-ihcscwxa7680272.shtml; Teamax Smart City Technology Co., Ltd., "[Teamax Smart City Technology Co., Ltd. 2018 Annual Report] (天夏智慧城市科技股份有限公司 2018 年年度报告全文)," June 2019: 1-199.
[21] PwC, "Creating the Smart Cities of the Future," May 2019, https://www.pwc.com/gx/en/sustainability/assets/creating-the-smart-cities-of-the-future.pdf.

status of smart cities development in China, detailing the role of institutional guidance from major regulatory and planning agencies like the Ministry of Industry and Information Technology and the National Development and Reform Commission in implementing Chinese smart cities policies. Chapter 3 expounds on China's use of smart cities technologies to surveil its population as an example of this type of policy implementation, and Chapter 4 describes Chinese efforts to export smart cities technologies abroad, including surveillance technology. In Chapter 5, this report concludes with a comparison of U.S. and Chinese approaches to smart cities development, assesses how firms from both countries that develop smart cities are competing in the global marketplace, and discusses the risks using Chinese smart cities components poses to U.S. critical infrastructure.

I | Chinese Smart Cities Policies: History and Current Practice

Key Findings

- Smart cities are part of a decades-long pattern of Chinese government programs that seek to digitize and "informatize" cities to improve China's comprehensive national power and internal strength.
- The central government's top-down approach for smart city pilot programs and shift away from city-led initiatives has led to the centralization of decision-making and the decentralization of implementation. This has resulted in a nonlinear and unpredictable development trajectory for Chinese smart cities that allows for experimentation and course-correction.
- Chinese smart cities policies have begun to coalesce and standardize after an initial period of experimentation and bureaucratic overlap.

This chapter provides historical context for China's current smart cities initiatives and describes current areas of emphasis. China's smart cities initiatives are in many senses a culmination of longstanding Chinese policy trends and should be understood as components of a broader Chinese approach to informatization policy that seeks to link military and civilian information technology development in the service of increasing China's comprehensive national power. A distinctive characteristic of the "Chinese model" of smart cities development is the way it couples centralization of decision-making with decentralization of implementation, as priorities are set by central authorities but pilot projects and other forms of experimentation are common at the local level.

Smart Cities Initiatives in Historical and Procedural Context

People's Republic of China's (PRC) Paramount Leader Xi Jinping has highlighted the importance of China's smart cities development with increasing frequency in his public speeches and proclamations, mirroring the Chinese state's prioritization of policies aimed at introducing smart cities technology into city governance.[22] While Chinese efforts to actively promote smart cities development are relatively new, Xi is already familiar with smart cities concepts; as he noted in a 2018 letter to the Digital China Summit, when Xi was governor of Fujian province nearly twenty years ago, he oversaw the construction and deployment of the "digital Fujian" project, a predecessor to modern smart cities initiatives.[23] Understanding the current state of smart cities

[22] "Full Text of President Xi's Speech at Opening of Belt and Road Forum," Xinhua, May 14, 2017, http://www.xinhuanet.com/english/2017-05/14/c_136282982.htm; Shan Zhiguang 单志广, "[Deepen Awareness of Advancing New Smart Cities Development] (深化认识推进新型智慧城市建设)," Qiushi Online, October 17, 2016, http://www.qstheory.cn/wp/2016-10/17/c_1119734160.htm.

[23] "[After Xi Jinping Sent A Congratulatory Letter, The Most Detailed 'Smart City' Interpretation Came] (习近平发贺信之后, 最详尽"智慧城市"解读来了)," National Business Daily, April 26, 2018, www.sohu.com/a/229574474_115362. For more information on Xi's substantial role in the Digital Fujian project, see Jens Damm, "China's E-policy: Examples of Local Government in Guangdong and Fujian," in *Chinese Cyberspaces: Technological Changes and Political Effects*, Jens Damm and Simona Thomas, eds., (New York: Routledge, 2006): 97-106.

policies and promotion efforts in China requires knowledge of the historical, bureaucratic, and strategic context in which they have been enacted.

China's current practice of smart city construction, and Xi Jinping's emphasis on the topic in his speeches and policymaking, represent the latest phase—and arguably the culmination—of two decades of Chinese endeavors to "informatize" (信息化) the governance and management of its cities.[24] Informatization is a concept without a single perfect equivalent in U.S. policymaking and strategic thought, but in its Chinese usage, it is generally defined as the drive to integrate information technology into every aspect of the state and society to build up China's comprehensive national power and internal strength. Chinese ideological and strategic writings frequently describe the era of informatization as the successor to the era of mechanization (机械化), and a constant theme in these writings is the idea that informatization processes in military and civilian realms are mutually reinforcing.[25]

As a result, China's civilian informatization policies have been designed to account for national security interests and augment China's military power whenever possible. China's smart cities policies are not *sui generis* efforts and should not be taken as such; as the latest in a long series of "urban informatization" policies, they exist as one component of a broader whole. This broader universe of informatization policies includes plans in areas such as "smart manufacturing," wherein information technology is expected to improve production capabilities across a wide range of industries, and the development of both China's civilian and military information technology industries in particular.

Chinese urban informatization policies have continuously evolved in accordance with a range of factors, including the state of domestic and global technology development, Chinese evaluations of prevailing policy trends abroad, and perhaps most importantly, the CCP's shifting assessments of the role that technology plays in maintaining Party control and internal stability. Over time, they have progressed from the "digital cities" (数字城市) initiatives of the late 1990s to the "information cities" (信息城市) of the mid-2000s to a more recent emphasis on "smart cities" (智慧城市) and "new smart cities" (新型智慧城市).[26] Transitions from one set of urban informatization policies to the next are often not clearly delineated because they function less as discrete policy packages and more as a general "brand" conveying the current priorities of the Chinese state. In concrete terms, they serve to inform entities within China's lower government tiers and the private sector where government funding and regulatory energy are likely to flow.

The result is a process that is often nonlinear and unpredictable. Pilot programs at the municipal and provincial levels frequently coexist with "previous generation" national-level policies before being either expanded or discarded according to their results. Policies are often primarily notional when they are first announced, with more concrete and impactful measures following in due course as central government bodies propagate more granular guidance fleshing out the meaning of

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[24] Wu Linjing 吴林静 and Liang Hongliang 梁宏亮, "[The 'Smart Cities' Concept Is Ten Years Old, How Many Solid Bones Does It Have?] ("智慧城市"概念十年落地, 还有多少硬骨头要啃?)," National Business Daily, April 26, 2018, http://www.nbd.com.cn/articles/2018-04-26/1212016.html.

[25] For much more detail on this topic, see Joe McReynolds and James Mulvenon, "The Role of Informatization in the People's Liberation Army under Hu Jintao," in *Assessing the People's Liberation Army in the Hu Jintao Era*, Roy Kamphausen, et al, eds., Carlisle, PA: U.S. Army War College Press, April 2014.

[26] Yu Wenxuan and Xu Chengwei, "Developing Smart Cities in China: An Empirical Analysis," *International Journal of Public Administration in the Digital Age* 5, no. 3 (July 2018): 76-91.

abstract statements from top leaders. Policies and programs enacted in one era under a certain label may continue onward into the next era and be re-labeled accordingly, such as how numerous pre-existing Chinese initiatives around the world have been folded into China's current "Belt and Road Initiative" in an attempt to make BRI appear more consequential. However, there is an observable theme: each phase of Chinese urban informatization policy has attempted to course-correct in light of the omissions or flaws in the implementation of the previous generation's policies while accounting for shifts over time in widely available technology and resources.

The Path to New Smart Cities

Since China's smart cities initiatives have evolved organically from earlier informatization policies over the course of decades, the differing scope of those policies in each prior era provides important context for understanding the current state of affairs. Digital cities policies beginning in the 1990s centered on initiatives of the State Bureau of Surveying and Mapping (国家测绘地理信息局), a now-defunct Chinese government ministry devoted to oversight of domestic cartographic activities that expanded its portfolio over time to encompass new digital surveying and mapping technologies. These primarily focused on what China terms the "3S" technologies—geographic information systems (GIS), global positioning systems (GPS), and remote sensing (RS)—in an attempt to expand the range of data available to government policymakers.[27] The mid-2000s concept of "information cities" focused on informatizing cities by bringing a wider range of existing government systems, such as those for municipal administration and urban infrastructure, into the digital age, including linking those systems with information technology and modernizing telecommunications infrastructure. And most recently, "smart cities" efforts aim to ease the flow of data between those government information systems via standardization and interoperability, all while collecting new forms of data through cutting-edge information technologies and offering an expanded range of government actors access to information relevant to their duties and decision-making. Generally speaking, each phase of programmatic development has been inclusive of the technologies emphasized in the previous phase rather than supplanting them.[28] These shifts are displayed chronologically in Table 2 below.

Table 2: Chronology of Chinese Urban Informatization Policies[29]

Year	Development Stage	Key Technologies	Primary Period of Implementation
1995	"Eight Gold Plan" (八金计划)	Foundational nationwide information infrastructure	9th Five Year Plan
1998	Digital Cities (数字城市)	"3S" Technologies (Geographic Information Systems, GPS, Remote Sensing)	10th Five Year Plan

[27] Jin Jiangjun 金江军, ed., *Leading Cadre Reader for Network Security and Informatization 网络安全和信息化党政领导干部读本* (Beijing: Central Committee Party School Press, 2017), 20.

[28] Yu Wenxuan and Xu Chengwei, "Developing Smart Cities in China: An Empirical Analysis," *International Journal of Public Administration in the Digital Age* 5, no. 3 (July 2018): 76-91.

[29] Jin Jiangjun 金江军, ed., *Leading Cadre Reader for Network Security and Informatization 网络安全和信息化党政领导干部读本* (Beijing: Central Committee Party School Press, 2017), 20.

2006	Information Cities (信息城市)	Information and Communications Technologies (ICT)	11th Five Year Plan
2009	Smart Cities (智慧城市) ["智能城市" and "感知城市" as lesser-used alternatives]	"New Generation Information Technologies" such as the IoT, cloud computing, pervasive mobile networks, and "big data" systems	12th and 13th Five Year Plans
2015	New Smart Cities (新型智慧城市)	Focused on Internet of Things, cloud computing, big data	13th Five Year Plan

The current dominant form of the smart cities concept, "New Smart Cities" (新型智慧城市), refers to the adoption of a new generation of information technology such as IoT, cloud computing, pervasive mobile networks, and big data systems to improve the level of intelligence and automation in urban planning and governance.[30] Within this broad scope, many of the concerns that China hopes to address with its smart cities programs are universal, such as the desire for more functional, efficient, and responsive local governance. Others, however, target more particular challenges that stem directly from China's choices in the recent past, such as China's promotion of rapid urbanization and industrialization through cheap labor and limited regulation. Although these policies have indeed led to rapid economic growth, the byproduct has frequently been unsustainable management of natural resources and a poor standard of living for the urban working class; in both areas, China hopes that smart cities technology will help improve the conditions.[31]

While the stated goals of PRC smart cities initiatives generally include anodyne universal goods such as increased safety and efficiency, improving the government's agility and perhaps even functioning to lower pollution, China's smart cities systems frequently appear to have also been designed to serve a social control function.[32] The CCP considers its own self-preservation and maintenance of power to be of paramount importance; in many cases elements of smart cities initiatives will ultimately help the CCP to identify and suppress any perceived threat to regime stability. This is particularly apparent in China's northwest province of Xinjiang, where smart cities technologies have been employed in concert with the forceful and violent repression of

[30] "[Guiding Opinions on Promoting the Healthy Development of Smart Cities] (关于促进智慧城市健康发展的指导意见)," National Development and Reform Commission, August 27, 2014, http://www.ndrc.gov.cn/gzdt/201408/W020140829409970397055.pdf.

[31] "[Promote High-Quality Urbanization, Accelerate the Construction of Smart Cities] (高质量推进城镇化 加快建设智慧城市)," Xinhua, August 30, 2018, http://www.xinhuanet.com/info/2018-08/30/c_137430643.htm; Yu Wenxuan and Xu Chengwei, "Developing Smart Cities in China: An Empirical Analysis," *International Journal of Public Administration in the Digital Age* 5, no. 3 (July 2018): 76-91.

[32] Megha Rajagopalan, "This Is What A 21st-Century Police State Really Looks Like," Buzzfeed News, October 17, 2017, https://www.buzzfeednews.com/article/meghara/the-police-state-of-the-future-is-already-here.

China's ethnic minority populations by the local authorities.[33] The resulting situation has been frequently and accurately described by investigative journalists and human rights activists as amounting to a "digital gulag," wherein facial recognition and other surveillance technologies ostensibly designed to improve public safety are being used to track and target China's Uyghur Muslim citizens on a societal scale. Even beyond repression in minority areas such as Xinjiang, smart cities initiatives provide a digital backbone that facilitates the consistent enforcement of social control programs such as social credit initiatives.

Xi's Increasing Smart Cities Emphasis

Xi Jinping has voiced his support for smart cities initiatives numerous times in his public speeches, going as far as to describe urban internet, cloud computing, and big data infrastructure as on the same level of importance as roads and bridges for urban planning.[34] Xi believes that building "new smart cities" and facilitating enhanced data collection and sharing among state organs will be key to achieving China's urban management objectives.[35] Xi appears to believe that because China is a rapidly developing country playing catch-up to the developed world, its cities are less burdened than cities in developed countries by legacy systems that have become outdated but are costly to modify or replace.[36] In Xi's view, if China is able to move decisively and prudently in its initial foray into smart cities development, Chinese cities will be able to reap the benefits of global technology development while bearing a smaller cost.

Xi also used a 2017 speech at the Belt and Road Initiative (BRI) Forum to support China's participation in smart cities projects in other nations pursuing greater trade with China.[37] This subset of the overall BRI effort has been variously termed the "smart Belt and Road" or "Digital Silk Road" by leading participants and state-sponsored Chinese media.[38] Frequently, these initiatives involve Chinese partnerships with foreign multinational corporations; the Chinese technology conglomerate Inspur, for example, entered into a partnership in 2017 with major foreign firms such as IBM, Cisco, and Ericsson to collaboratively tackle smart cities projects ranging from smart urban management and taxation to finance and education in BRI-participating countries.[39] In Sofia, Bulgaria, Chinese private and state-run companies are receiving local

[33] Megha Rajagopalan, "This Is What A 21st-Century Police State Really Looks Like," Buzzfeed News, October 17, 2017, https://www.buzzfeednews.com/article/meghara/the-police-state-of-the-future-is-already-here.
[34] Shan Zhiguang 单志广, "[New Trends in the New Type of Smart City Development] (新型智慧城市发展的新形势)," June 17, 2018, http://www.besticity.com/viewpoint/219707.html.
[35] "[Xi Jinping: We Must Deeply Understand The Internet's Work In State Management and Social Governance] (习近平：要深刻认识互联网在国家管理和社会治理中的作)," Shandong Province Department of Culture and Tourism, October 10, 2016, http://www.sdwht.gov.cn/html/2016/llqy_1011/36909.html.
[36] Roger Creemers, Paul Triolo, and Graham Webster, "Translation: Xi Jinping's April 20 Speech at the National Cybersecurity and Informatization Work Conference," April 30, 2018, https://www.newamerica.org/cybersecurity-initiative/digichina/blog/translation-xi-jinpings-april-20-speech-national-cybersecurity-and-informatization-work-conference/; Wu Linjing 吴林静 and Liang Hongliang 梁宏亮, "[The 'Smart Cities' Concept Is Ten Years Old, How Many Solid Bones Does It Have?] ("智慧城市"概念十年落地, 还有多少硬骨头要啃?)," National Business Daily, April 26, 2018, http://www.nbd.com.cn/articles/2018-04-26/1212016.html.
[37] "Full Text of President Xi's Speech at Opening of Belt and Road Forum," Xinhua, May 14, 2017, http://www.xinhuanet.com/english/2017-05/14/c_136282982.htm.
[38] David Gosset, "Time to Join Hands for A 'Smart Belt and Road,'" China Daily, April 11, 2019, http://www.chinadaily.com.cn/a/201904/11/WS5cae97b3a3104842260b58bf.html and Liu Meng 刘梦, "Big Data Lays "Digital Silk Road,"" May 14, 2019, https://eng.yidaiyilu.gov.cn/DigitalValley/HotNews/90575.htm.
[39] Zhang Liying, "Building Smart Cities with Big Data Along the Digital Silk Road," April 26, 2019, http://www.china.org.cn/business/2019-04/26/content_74724519.htm.

government incentives to participate in BRI smart cities projects.[40] Chinese BRI projects and other smart cities investments abroad are discussed in more detail in the following chapters.

Xi's Focus on the Xiong'an New Area

Xi Jinping frequently cites the example of the recently established Xiong'an New Area (雄安新区) southwest of Beijing as a model for future smart cities development within the PRC. From the beginning of his term as president, Xi has emphasized the need for coordinated development between Beijing and nearby port city Tianjin, arguing that this planned de-centralization of China's capital region will eventually serve as a model for "socialist modernization in the new era."[41] Xiong'an New Area has been rolled into accelerated development of the Beijing-Tianjin-Hebei corridor, the latter of which Xi described to former U.S. Treasury Secretary Hank Paulson in July 2014 as "his own personal initiative."[42] For a brief history of the Xiong'an New Area, please see Box 1.

Box 1: Xiong'an New Area

Development of the Xiong'an New Area began in 2017 and the project is still considered to be in its initial phases.[43] Although the Area already extends across 100 square kilometers, it is expected to eventually grow to more than 2,000 square kilometers; if this comes to pass, the Xiong'an New Area would encompass more than double the land area of New York City.[44] A 2019 planning document issued by the Central Party Committee identified the region as one of China's "key economic development zones," second only to the Shenzhen Special Economic Zone (继深圳经济特区) and the Shanghai Pudong New Area (上海浦东新区).[45] Xiong'an is expected to focus on attracting research, development, and manufacturing firms in high-tech industries, including information technology, biotechnology, and new materials. Intelligent, technologically advanced urban services such as roads designed for smart cars and renewable energy infrastructure are being used to augment Xiong'an's attractiveness as a research and manufacturing hub.

The Central Party Committee correspondingly has pledged to develop the Xiong'an New Area by providing it with extensive monetary and institutional support, even going so far as to publicize its intention to relocate many non-critical government functions there that are currently clustered in

[40] He Wei, "Sofia Smart City Project Gets Chinese Funding," China Daily, March 28, 2019, http://www.chinadaily.com.cn/a/201903/28/WS5c9c5fc5a3104842260b314c.html.

[41] "[A Wonderful Start to the Millennium Plan: Xi Jinping Promotes The Construction of Xiong'an]" (千年大计 精彩开局 习近平这样推进建设雄安), CCTV.com, February 23, 2019, http://news.cctv.com/2019/02/23/ARTIHIkPtewTv5ANHggj241t190223.shtml.

[42] "[July 2014, Momentous Xiong'an Thought. The Book Has Gold!] (2014 年 7 月，大大的雄安设想。书中真有黄金，屋)," Xueqiu.com, http://web.archive.org/web/20170405170331/https://xueqiu.com/6847723845/83493804.

[43] "[A Wonderful Start to the Millennium Plan: Xi Jinping Promotes The Construction of Xiong'an] (千年大计 精彩开局 习近平这样推进建设雄安)," CCTV.com, February 23, 2019, http://news.cctv.com/2019/02/23/ARTIHIkPtewTv5ANHggj241t190223.shtml.

[44] "[Xiong'an New Area Millennium Development Plan] (雄安新区千年大计)," Qianhai Alliance Asset Management Fund, June 19, 2017, http://www.qhlhfund.com/upload/user/1/2017-6-19/195400706838.pdf.

[45] Central Committee of the Chinese Communist Party and State Council of the People's Republic of China, "[Guiding Opinion Regarding Support of Deepening Reforms and Expanding the Hebei Xiong'an New Area](中共中央 国务院关于支持河北雄安新区全面深化改革和扩大开放的指导意)," January 24, 2019, http://www.gov.cn/zhengce/2019-01/24/content_5360927.htm.

downtown Beijing.[46] The Xiong'an New Area's various smart city initiatives are designed to support this growth plan; however, they do not appear to follow a single unifying strategy. The special economic zone (SEZ)'s announced smart cities projects range from facial recognition technology and smart utilities to Alibaba's "city brain" platform.[47] As the SEZ moves closer to a proper launch, the ways in which smart cities technologies directly facilitate its success may become clearer.

Current Smart Cities Policy and the Chinese Regulatory State

China's smart cities policies have evolved in three main directions over the past decade: towards more centralization of authority on smart cities; greater harmonization of responsibilities among fractious, competitive government bureaucracies; and a sharper focus on specific key technologies under the "new smart cities" concept.

Roughly from 2009 onwards, perhaps the most distinctive characteristic of the "Chinese model" of smart cities development has been its centralization of decision-making and decentralization of implementation. Early smart cities projects began to launch in 2009, with individual cities taking the initiative to explore technological solutions to governance challenges.[48] Ningbo, a populous and highly developed coastal city in Zhejiang province, holds the distinction of being the first city in China to publish a smart cities plan in 2010; a range of other cities quickly followed suit. Foreign multinationals such as IBM and Cisco, perhaps sensing the potential to open a vast new market, directly encouraged these efforts and entered into technology sharing pilot projects with Chinese counterparts.[49]

However, this bottom-up approach was rapidly overtaken by top-down pilot programs emanating from the central government. The Chinese government's 12th Five Year Plan, issued in 2010, included language specifically encouraging the planning and development of smart cities, directing state resources toward the development of software, internet technology infrastructure, smart devices, mobile networks, enterprise applications, infrastructure, and operational smart cities services as pieces of the overall effort. Funding and selecting smart cities projects came under the central government's purview, although participating local municipalities have retained the authority to manage their own projects under the guidance of relevant central ministries and are often consulted in the planning process about their specific needs and capabilities.

The Chinese central government bureaucracy's once-fractious authorities over smart cities initiatives have also evolved and been harmonized over time. In this early stage of smart cities development, various key players within China's sprawling ministerial bureaucracies have staked out oft-overlapping roles for themselves in the regulation and promotion of smart cities projects. From 2012 onward, China's Ministry of Housing and Urban-Rural Development (住房和城乡建设部 or MOHURD), China's main government authority in charge of urbanization, urban planning,

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[46] Central Committee of the Chinese Communist Party and State Council of the People's Republic of China, "[Guiding Opinion Regarding Support of Deepening Reforms and Expanding the Hebei Xiong'an New Area] (中共中央 国务院关于支持河北雄安新区全面深化改革和扩大开放的指导意)," January 24, 2019, http://www.gov.cn/zhengce/2019-01/24/content_5360927.htm.

[47] Fatoumata Diallo, "Xiong'an: A New Model of Digital Chinese Urbanism," December 2018, http://isdp.eu/publication/xiongan-a-new-model-of-digital-chinese-urbanism/.

[48] Yu Wenxuan and Xu Chengwei, "Developing Smart Cities in China: An Empirical Analysis," *International Journal of Public Administration in the Digital Age* 5, no. 3 (July 2018): 76-91.

[49] Aaron Back, "IBM Launches a 'Smart City' Project in China," *Wall Street Journal,* September 17, 2009, https://www.wsj.com/articles/SB125311797322316391.

urban management, and public housing, has been selecting cities in which to experiment and implement smart cities initiatives. By 2015, China had nearly 300 MOHURD-sponsored localities with smart cities initiatives.

MOHURD documents from 2012 (such as the *Notice of Implementing National Smart City Pilot Projects*, *National Interim Measures for Smart City Pilot Projects*, and *Guidance on Promoting the Sustainable Development of Smart Cities*) formed the regulatory basis for this effort, while the state-run China Development Bank provided funding totaling $16 billion USD.[50] Participants also self-funded in part through Local Government Financing Vehicles (LGFVs), which enabled cities to raise funds through a combination of bank loans, bonds, and equity market public offerings.[51]

Other ministries were similarly busy. As MOHURD was launching its pilot projects in 2012, the Ministry of Science and Technology (MOST), along with the National Development and Reform Commission (国家发展和改革委员会 or NDRC) and the Ministry of Industry and Information Technology (工业和信息化部 or MIIT), separately formed the China Strategic Alliance of Smart City Industrial Technology Innovation, the first of several smart cities industrial alliances. These various alliances' functions include funding research and projects, developing smart cities technologies, formulating industry standards, and offering smart cities solutions to local governments. These efforts have resulted in government documents such as the *Guidance on Promoting Healthy Smart City Development* (关于促进智慧城市健康发展的指导意见), which offer a fairly clear delineation of the boundaries of a "smart city," defining it as a "new concept and model which utilizes the next generation of information technology, such as IoT, cloud computing, and big data to promote smart urban planning, construction, management, and service offerings for cities," and providing basic principles, objectives, and action plans for smart cities development.

Over time, inter-ministerial jockeying gave way to more active central government coordination. In 2014, China's State Council released the *National New-Type Urbanization Plan 2014-2020* (国家新型城镇化规划 or NUP), an effort spearheaded by the NDRC but carried out with the cooperation of a dozen relevant government ministries.[52] The Standardization Administration of China (国家标准化管理委员会 or SAC) was tasked with overseeing new inter-ministry working groups to manage and standardize disparate smart cities development projects.[53] Collectively, these choices aimed to further promote smart cities projects in small and medium-sized cities while promoting a greater harmonization of effort between different government ministries.

However, bureaucratic harmony was not in and of itself sufficient to fully resolve the lingering challenges China's smart cities initiatives faced. By 2016, although China's smart cities programs

[50] Don Johnson, "Smart City Development in China," *China Business Review*, June 17, 2014, https://www.chinabusinessreview.com/smart-city-development-in-china/.
[51] A comparative analysis of smart city initiatives by China and India - Lessons for India.
[52] Jack Maher and Xie Pengfei, "China's New Urbanization Plan: Obstacles and Environmental Impacts," Smart Cities Dive, https://www.smartcitiesdive.com/ex/sustainablecitiescollective/china-s-new-urbanization-plan-obstacles-and-environmental-impacts/246981/.
[53] Dang Anrong 党安荣, Zhen Maocheng 甄茂成 et al. "[China's Development and Trends in New Smart Cities] (中国新型智慧城市发展进程与趋势)," November 17, 2018, https://www.iyiou.com/p/85632.html.

had by all accounts made considerable progress, a speech by a senior central government policymaker nevertheless identified five key flaws in the current state of affairs:[54]

- Projects were blindly following highly publicized trends in smart cities construction without clear goals.
- Coordination and power-sharing measures between ministries were insufficient.
- There were too many pilot projects coupled with insufficient learning from completed projects.
- There was a lack of innovation in institutional mechanisms for smart cities.
- Inadequate consideration had been given to information security concerns.

Following this assessment, processes for harmonization were more strictly institutionalized in a document titled *Division of Effort for Construction of Inter-Ministerial Coordination Working Groups on New Smart Cities 2016-2018* (新型智慧城市建设部际协调工作组 2016-2018 年工作分工). Since its issuance, policy and institution-building efforts have featured collaboration among Chinese ministries as a key component. In April 2016, in accordance with the *Division of Effort* document, the NDRC and the Cyberspace Administration of China (中央网络安全和信息化委员会办公室 or CAC) jointly launched the Inter-Ministerial Coordination Working Group on New Smart Cities (新型智慧城市部际协调工作组) under the aegis of the SAC with at least tertiary participation from up to two dozen government bodies.[55] This effort resulted in the joint issuance by all three bodies of the *New Smart Cities Evaluation Index* (新型智慧城市评价指标), which aimed to clarify the direction and priorities of China's smart cities efforts by gauging progress against eight key indicators: service to the people, precision in governance, ecological sustainability, intelligent facilities, access to and use of information resources, cybersecurity, reform and innovation, and the quality of the citizen experience.[56]

Having established a workable division of responsibilities within its bureaucracy, the Chinese central government has now turned its focus to ensuring that smart cities programs are centered in top-level government policies, swiftly and thoroughly implemented, and properly targeted at municipal government needs. Smart cities were given unprecedented attention in China's 13th Five Year Plan (FYP) spanning from 2016 to 2020, a document that serves as the central government's primary guidance on policy prioritization. In the 13th FYP, smart cities are a major focus, with special emphasis placed on building up a number of exemplar cities and areas (such as the previously mentioned Xiong'an New Area). This was the first time that the phrase "new smart cities" appeared in a high-level Chinese policy document.

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[54] National Geographic Survey Information Administration (国家测绘地理信息局), "[Deputy Minister Li Weisen Answers Media Questions About the Division of Labor for Xiong'an New Area Construction and Basic Infrastructure Construction] (李维森副局长就新型智慧城市建设 2016-2018 任务分工及智慧城市时空基础设施建设答记者问)," September 1, 2016, http://www.mnr.gov.cn/dt/ch/201609/t20160901_2345840.html.

[55] Informatization Research Department (信息化研究部), "[New Smart City Construction Department Coordination Work Group Secretariat Opens Second Contact Person Meeting] (新型智慧城市建设部际协调工作组 秘书处组织召开第二次联系人会)", State Information Center (国家信息中心), December 13, 2016, http://www.sic.gov.cn/News/260/7308.htm.

[56] Dang Anrong 党安荣, Zhen Maocheng 甄茂成 et al. "[China's Development and Trends in New Smart Cities] (中国新型智慧城市发展进程与趋势)," November 17, 2018, https://www.iyiou.com/p/85632.html.

Perhaps in response to the FYP's guidance, smart cities were soon being integrated into a wide range of relevant Chinese policies. December 2016 saw the release of the *13th Five Year Plan for National Informatization 2016-2020* ("十三五"国家信息化规划), which lays out top-level plans for how each ministry will implement the corresponding *National Informatization Development Strategic Outline* (国家信息化发展战略纲要) and calls for the integration of national databases as well as the interoperability of government networks and services across different departments, regions, and levels of government by 2020.[57] In the document's explicit hierarchy of priorities, smart cities construction was named as one of twelve "priority actions" (优先行动) demanding government attention. The report of the 19th Party Congress in October 2017 similarly embodied this full-speed-ahead ethos, as encapsulated in its exhortation that China must build itself into a "cyber power, a digital country, and a smart society."[58] Chinese analysts interpreted the newly-coined phrase "smart society" (智慧社会) as intended to encompass both smart cities initiatives and similar rural information technology projects.[59]

At the same time as the bureaucratic trends surrounding smart cities initiatives were shifting, the emphasis of the initiatives themselves was evolving as well. Numerous official and quasi-official Chinese sources speak of China's "new smart cities" concept as distinct from the previous "smart cities" in its more defined development direction, which centers on four key lines of effort (四个重点) and six practical applications for those efforts (六个一 or 六个体验应用). The four lines of effort include developing:[60]

- Internet of Things architectures using openly disseminated and interoperable standards (物联网开放体系架构), particularly an IoT open architecture solution[61] using indigenously developed intellectual property and relevant supporting infrastructure.
- Urban open information platforms (城市开放信息平台), including municipal service platforms that can integrate with big data sources. The goal of this effort is to build a data-sharing ecosystem that eliminates the all-too-frequent "isolated information islands" within various levels of Chinese governance.

[57] "State Council Releases Five-Year Plan on Informatization," State Council of the People's Republic of China, December 27, 2016, http://english.gov.cn/policies/latest_releases/2016/12/27/content_281475526646686.htm.
[58] China Center for Urban Development, Smart City Development Alliance, "The Fourth China Smart City International Expo 2018," August 21, 2018, https://www.jc-web.or.jp/publics/download/814/2260/1314/?file=/files/content_type/type019/1314/201806041049331094.pdf.
[59] Shan Zhiguang 单志广, "[New Trends in the New Type of Smart City Development] (新型智慧城市发展的新形势)," June 17, 2018, http://www.besticity.com/viewpoint/219707.html.
[60] Fu Yizhou 傅义洲, "[Smart Cities Based On One Platform and One Network Intrinsically Help Raise Governance and Service Capability] (新型智慧城市基于一个平台一张网 本质在提升治理服务体系能力)," Xinhua, March 13, 2016, http://www.gov.cn/xinwen/2016-03/13/content_5052889.htm; Ren Qinfeng 任青锋 and Chen Yongsheng 陈永生, "[The "Light of the Internet Conference" Opens, CETC's New Smart City Illuminates Internet Meeting] (乌镇直击 | 互联网之光博览会今日开幕，中国电科"新型智慧城市"点亮互联网大会)," China Electronics Technology Group Corporation, https://mp.weixin.qq.com/s?__biz=MzUzOTU3MjIxNw==&mid=2247500472&idx=1&sn=e5c56feabcf52d26b7b02887513c2c82.
[61] Open architecture refers to a computer or software design architecture intended to make adding, upgrading, or exchanging components of a system easier.

- Urban operation command centers (城市运行指挥中心) that provide access to useful data for governance, enabling coordination across government departments and improving emergency response efficiency.
- Cybersecurity systems (网络空间安全体系) which can be deployed across the above lines of effort, including systems to protect urban infrastructure and urban data centers.

The six practical applications emphasized in the "new smart cities" concept include:[62]

- Open systems architectures (开放的体系架构), which are to be constructed in accordance with established standards for smart cities systems construction and systems engineering methodologies, with the goal of strengthening information-sharing, integrating systems, and offering open applications.
- Land- and space-based integrated grid networks (天地一体的栅格网), sometimes referred to as urban information services grid networks, which will serve as a consolidated foundation for new smart cities construction and enable cities to reap the benefits of integrating their sensing and information systems with public services.
- Interoperable and function-specific municipal governance platforms (通用功能平台), enabling the smooth management of a wide variety of information resources and the intelligent, efficient provision of urban resources, management, and public services.
- Open shared data systems (开放共享的数据体系), allowing for the rapid integration and analysis of large quantities of data through standardization and integration, increasing the production and use of data for decision-making support in order to improve urban governance.
- Efficient operation centers (高效的运行中心), which will realize the convergence and sharing of urban resources and enable improved inter-departmental coordination, providing support for efficient and precise urban management as well as safer and more reliable operation of city facilities and services in areas ranging from ecology to public security and public opinion management.
- Unified standards systems (统一的标准体系) to enable the orderly and healthy development of new smart cities. These standards-setting efforts are to be led by government entities and must take into account the varied characteristics of individual cities, spanning the construction, reform, and evaluation processes.

These declarations of state priorities are not merely theoretical; they have been matched in recent years by government action. Since the release of the 13th Five Year Plan, organizations across China's regulatory state have produced a range of increasingly granular policy outlines that reflect these emphases, such as the National Surveying and Mapping Geographic Information Bureau's 2017 *Outline on the Construction of Spatio-temporal Big Data and Cloud Platforms for Smart Cities* (智慧城市时空大数据与云平台建设技术大纲) and the NDRC's annual *Notice on Organizing the Implementation of Next Generation Information Infrastructure Construction Projects* (关于组织实施新一代信息基础设施建设工程的通知). The latter policy has served as

[62] "[CETC: Six Essential Things in New Smart City Construction] (中电科技：新型智慧城市建设的六项关键)," China Securities Network, December 17, 2015, http://finance.ifeng.com/a/20151217/14127880_0.shtml.

the impetus for funding a range of digital infrastructure and city networking hardware in small and medium-sized cities in China's traditionally less developed interior provinces.[63] This trend is likely to continue until the next reassessment of priorities in 2020.

[63] "[Notice on Organizing the Implementation of Next Generation Information Infrastructure Construction Projects] (关于组织实施 2019 年新一代信息基础设施建设工程的通知)," National Development and Reform Commission, 2018, http://gjss.ndrc.gov.cn/ghzc/201812/t20181211_922482.html.

II | Chinese Smart Cities Development Trends

Key Findings

- The development of Chinese smart cities technology is primarily top-down, driven by government investment, and generally aligns with regional development patterns, with the bulk of projects lining China's more economically-developed eastern seaboard.
- Estimates of the size of the smart cities solutions market in China vary widely and their reliability is somewhat unclear; Chinese consulting firms have bullishly pegged the market at RMB 7.9 trillion ($1.1 trillion) in 2018 and project that it will grow at a 33 percent compound annual growth rate between 2018 and 2022.
- Chinese municipal authorities charged with smart cities development commonly cite transportation, public services, public safety, education, healthcare, and environmental protection as focus areas for Chinese smart cities projects.
- While there are numerous noted examples of successful deployment of smart cities solutions in China, many challenges still exist, including long-term program sustainability, insufficient information-sharing mechanisms between governing authorities, and a dearth of accurate information about actual progress in smart city development funding and implementation. Together, these deficiencies may hinder a broader embrace of smart cities across China.

Since the State Council's Ministry of Housing and Urban-Rural Development (MOHURD) approved its first group of 90 smart cities pilot projects in 2012, Chinese cities have continued to push increasingly ambitious efforts to implement information technology-based solutions for smart city management and public services. As of early 2019, a Chinese industry study placed the total number of smart cities pilot projects in China at nearly 800, including approximately 300 projects certified by MOHURD, the Chinese central government's largest sponsor for such initiatives, as well as projects supported by the NDRC, MIIT, and other ministries.[64]

While the most commonly used Chinese term for smart city, *zhihui chengshi* (智慧城市), has gained broad acceptance in policymaking and business circles, it is not rigorously defined as a technical term and in practice there is significant variation in the content of local smart cities projects, which range from small-scale efforts to promote tourism through mobile services to comprehensive city management platforms featuring live video feeds and data visualization capabilities for monitoring traffic, public security, and population information in real time. This chapter highlights selected features of China's smart cities landscape as it has evolved, including overall development trends; characteristic smart cities goals, technologies, and management mechanisms; major commercial suppliers of smart cities components and services; and future development prospects.

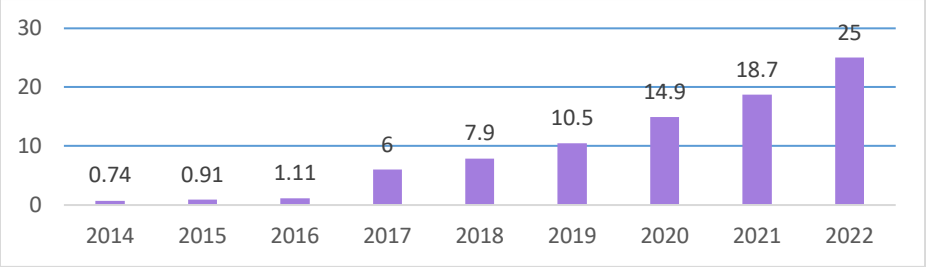
[64] "2019 Market Layout: Outlook on 2019 China Smart City Development Competitive Landscape (Including Market Share, Enterprise Comparison, Competitive Prospects) (2019 市场格局:《2019 年中国智慧城市建设竞争格局全局观》(附市场份额、企业经营对比、竞争前景))," Qianzhan Industry Research Institute, June 19, 2019, https://www.qianzhan.com/analyst/detail/220/190618-4ce4b615.html.

Government-led Smart Cities Development

China's smart cities development efforts have benefited from substantial central and local government investment. Smart cities pilot projects are estimated to have received more than RMB 1 trillion ($139.9 billion) in government investment to date,[65] and one market intelligence forecast suggested that Chinese government spending on smart cities initiatives would reach $38.92 billion in 2023. More than half of these funds are predicted to go to the priority fields of resilient energy and infrastructure projects, data-driven public safety, and intelligent transportation, but smart cities investments are also expected to diversify over time.[66]

These investments have helped to grow a Chinese market for smart cities solutions. Estimates of the size of the Chinese smart cities market vary widely: one Indian market research company pegged the 2018 value of the Chinese market at $30.4 billion and projected that it would reach $59.9 billion by 2023 at an 15.4 percent compound annual growth rate.[67] Even this number would account for a large proportion of what other sources estimate is the global value of the smart cities market,[68] but Chinese news outlets like *China Daily* have publicized far larger numbers, noting that Chinese consulting companies value the smart cities market at RMB 7.9 trillion ($1.1 trillion) in 2018 and project that it will reach RMB 25 trillion ($3.5 trillion) by 2022, reflecting an anticipated 33 percent compound annual growth rate.[69]

Figure 1: Estimated Chinese Smart Cities Market Size, 2014-2022 (RMB trillion)



Source: Qianzhan Industry Research Institute (前瞻产业研究院).[70]

Government funding has also promoted academic and applied research into smart cities concepts and technologies. The National High Technology Development Program (国家高技术研究发展

[65] "Smart Cities to Bring Smart Solutions," *China Daily*, December 14, 2018, http://en.people.cn/n3/2018/1214/c90000-9528772.html.
[66] Yirou, "Investment in China's Smart Cities to Approach 39 Bln USD by 2023: Report," Xinhua, July 14, 2019, http://www.xinhuanet.com/english/2019-07/14/c_138225586.htm.
[67] "China Smart Cities Market worth $59.9 billion by 2023," MarketsandMarkets, https://www.marketsandmarkets.com/PressReleases/china-smart-city.asp.
[68] Global market size estimates are discussed further in Chapters 4 and 5 of this report, in which different sources cited estimated global value in 2018 at $71.3 billion and $104.6 billion, and anticipate that growth rates of 18.9 and 16.4 percent respectively. Divergence in these figures may arise from discrepancies in the scope of technologies or industries considered. Analysts were unable to find more precise descriptions of how these estimates were reached.
[69] "Smart Cities to Bring Smart Solutions," *China Daily*. See also "2019 China Smart City Industry Market Analysis: Policies Favor Development, Three Key Issues Remain Unresolved (2019 年中国智慧城市行业市场分析:政策利好建设,三个核心问题亟待解决)," Qianzhan Industry Research Institute, February 26, 2019, https://bg.qianzhan.com/report/detail/300/190226-6493a8ba.html.
[70] "2019 China Smart City Industry Market Analysis: Policies Favor Development, Three Key Issues Remain Unresolved (2019 年中国智慧城市行业市场分析:政策利好建设,三个核心问题亟待解决)," Qianzhan Industry Research Institute, February 26, 2019, https://bg.qianzhan.com/report/detail/300/190226-6493a8ba.html.

计划), also known as the 863 Program, has reportedly played a particularly important role in developing underlying technologies with significance for smart cities programs, including government big data, cloud computing, and the IoT. Under direction from MOST, the 863 Program has also organized research projects to develop smart cities design models, overall system architectures, and digital solutions for city operations management.[71]

While China's government has taken a leading role in investing in initial smart cities development and technological R&D, since 2014 it has begun to encourage commercial enterprises and financial institutions to play a larger role in financing and operating smart cities projects via public-private partnership (PPP) models.[72] A key impetus for this shift was the government's expectation that the investment burden for future urbanization would quickly increase beyond what it could reasonably afford, which led to a series of new government policies aimed at encouraging non-government capital to invest in infrastructure and public services projects.[73] By the end of 2017, at least eleven PPP demonstration projects specifically focused on smart cities infrastructure were underway, with planned investments of over 20 billion RMB ($2.8 billion).[74]

The Geography of Smart City Pilots

The geographic distribution of Chinese smart cities projects generally aligns with regional economic development patterns. Figure 2 maps the location of 290 smart city pilot projects approved by MOHURD to date, showing relatively large numbers of projects in China's more developed eastern and southern coastal areas, with comparatively fewer initiatives in China's west.

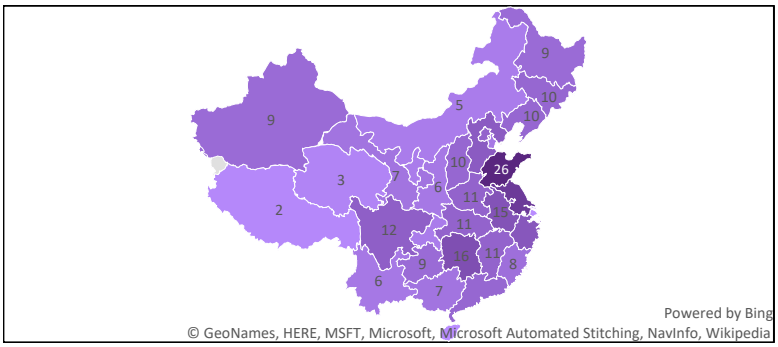
[71] "Smart City 863 Program Achievements and Development," Z-Park Strategic Alliance of Smart City Industrial Technology Innovation, October 20, 2016, http://www.smartcityunion.cn/index.php?m=content&c=index&a=show&catid=77&id=3115.

[72] "PPP Models Help Promote Smart Cities – Ten Images Help You Understand the State of Smart City PPP Development (PPP 模式助推智慧城市 十张图带你了解智慧城市 PPP 建设现状!)," Qianzhan Industry Research Institute, May 13, 2018, https://www.qianzhan.com/analyst/detail/220/180511-802a4fbf.html; see also Cui Ying, "Development and Practice of Smart City in China," CAICT Industry and Planning Research Institute, November 3, 2017, https://www.itu.int/en/ITU-D/Regional-Presence/AsiaPacific/SiteAssets/Pages/Events/2017/Oct2017CIIOT/CIIOT/15.Session5-5%20Development%20and%20Practice%20of%20Smart%20City%20in%20China-崔颖 V2red.pdf.

[73] Michel Brekelmans, "China Must Put the 'Private' into PPP," Nikkei Asian Review, May 17, 2018, https://asia.nikkei.com/Opinion/China-must-put-the-private-into-PPP2; Zhang Yanqiang 张延强, "[An Analysis of China's Current Development of Public-Private Partnerships and Some Policy Proposals] (我国政府和社会资本合作发展现状分析及对策建议)," December 31, 2016, http://www.sic.gov.cn/archiver/SIC/UpFile/Files/Htmleditor/201702/20170203131348155.pdf.

[74] Xu Jing 徐静, "[Implementation Status and Strategies of Smart City PPP Projects in China] (PPP 模式下我国智慧城市项目实施现状与策略研究)," *Science and Technology for Development 科技促进发展* 13, no. 10 (2017): 779-785.

Figure 2: MOHURD-certified Smart City Pilot Projects by Chinese Province



Source: List reprinted from MOHURD via Taibo Net.[75]

Chinese analysts point out that smart cities projects in more affluent cities are typically more successful as a result of greater local economic resources.[76] In addition, residents of areas with relatively strong information technology economies are more likely to demand smart city services from their local governments and are better positioned to take advantage of smart services as they become available.[77] It is unsurprising, then, that first-tier Chinese cities such as Shanghai, Beijing, Hangzhou, and Shenzhen generally rank highest in terms of smart city technical capability and services.[78] However, second- and lower-tier cities enjoy more freedom to innovate with fewer bureaucratic restrictions and may therefore play a larger role in prototyping new technologies and service models.[79]

Smart Cities Goals: Public Services, Management Efficiency, and Economic Development

In their overall objectives, Chinese smart cities projects are characterized by a focus on supporting city management and delivering services to promote well-being and economic development. An emphasis on providing direct benefits to residents, rather than simply making city administration more efficient, can be traced both to the NDRC's 2014 *Guiding Opinion on Promoting Smart City Healthy Development* (关于促进智慧城市健康发展的指导意见) and a government work report delivered by Premier Li Keqiang in the same year that called for "human-centric new-style

[75] "三批国家智慧城市名单（290 个）全在此，快来看看吧！[The List of The Three Batches of National Smart Cities Is All Here, Quickly Come Look!]," 泰伯网 [Taibo Net], September 18, 2016, http://www.3snews.net/column/252000043458.html.

[76] Yu Wenxuan and Xu Chengwei, "Developing Smart Cities in China: An Empirical Analysis," *International Journal of Public Administration in the Digital Age* 5, no. 3 (July-September 2018), https://www.researchgate.net/publication/311417191_Developing_Smart_Cities_in_China_An_Empirical_Analysis.

[77] "Digital Inclusion – Key to Prosperous and Smart Cities," Wireless Broadband Alliance, 2019, https://wballiance.com/digital-inclusion-key-to-prosperous-smart-cities/.

[78] Informally, Chinese cities are often grouped into several unofficial tiers or levels (*dengji*) based on size, GDP, administrative hierarchy, and other factors. See Dorcas Wang, "China's City-Tier Classification: What They Are and How Are they Defined," Dezan Shira & Associates China Briefing, February 27, 2019, https://www.china-briefing.com/news/chinas-city-tier-classification-defined/.

[79] "Super Smart City: Happier Society with Higher Quality," Deloitte China, 2018, https://www2.deloitte.com/content/dam/Deloitte/cn/Documents/public-sector/deloitte-cn-ps-super-smart-city-en-180629.pdf.

urbanization."[80] These goals are reflected in national-level smart cities documents such as a 2018 standard from the Standardization Administration of China, which describes a smart city as "an innovative city model applying information and communications technologies to connect urban management systems, share information resources and coordinate work between city systems, promote smart city management and services, upgrade city operations management and public service levels, increase the happiness and satisfaction of urban residents, and promote sustainable development."[81]

Chinese smart cities development guidelines and action plans issued by Chinese cities over the past several years reflect these priorities. The table below highlights major components of plans from one first-tier city (Shanghai), one second-tier city (Hangzhou), and one third-tier city (Heze, Shandong province), showing that while specific development targets may vary, cities of all sizes generally expect smart cities solutions to upgrade citizen services, improve administrative efficiency, and foster economic growth.

Table 3: Smart City Development Areas Identified in Smart City Planning Documents from Three Municipalities

Smart City Plan	Major Smart City Development Areas
Shanghai Three-Year Action Plan for Smart City Development, 2014-2016 (上海市推进智慧城市建设行动计划 [2014-2016])[82]	**Public services**: Smart transportation, smart healthcare, smart education, smart elder care, smart culture, smart tourism, smart employment, smart weather, smart communities. **City management**: Management informatization, food safety informatization, environmental protection informatization, public security informatization, smart water, electricity, oil, and gas infrastructure. **Smart economy**: Online finance, smart logistics, smart commerce, smart manufacturing, smart enterprises, smart shopping districts, smart business parks.
"Digital Hangzhou" /"New-Style Smart Hangzhou" Smart City Development Plan, 2017 ("数字杭州" ("新型智慧杭州"一期）发展规划)[83]	**Public services**: Smart education, smart healthcare, smart social security, smart community services, smart poverty alleviation, smart culture, smart tourism, smart agriculture, smart weather. **Precision government**: Smart transportation, smart policing, smart urban management, smart market supervision, smart surveillance, smart inspections, smart Party work, smart auditing, smart environmental protection, smart credit. **Economic development**: AI industry, big data industry, IoT industry, smart manufacturing, smart cross-border e-commerce.
Heze (Shandong) Guiding Opinion on Strengthening Smart	**Public services**: Information services covering education, culture, healthcare, social security, transportation, environmental protection, housing, sanitation, tourism, elder care.

[80] "Promoting Human-Centric New-Style Urbanization," (推进以人为核心的新型城镇化), Xinhua, modified March 5, 2014, http://www.gov.cn/zhuanti/2014-03/05/content_2635252.htm. See also "Guiding Opinion on Promoting Smart City Healthy Development (关于促进智慧城市健康发展的指导意见)," National Development and Reform Commission, 2014, http://www.ndrc.gov.cn/gzdt/201408/W020140829409970397055.pdf.

[81] "GB/T 37043-2018: Smart City – Terminology" (智慧城市 术语), Standardization Administration of China, December 28, 2018, http://www.besticity.com/ministries/246362.html.

[82] "Shanghai Action Plan to Promote Smart City Development (2014-2016) (上海市推进智慧城市建设行动计划 [2014-2016])," Shanghai Economic and Informatization Commission (上海经济和信息化委员会), December 17, 2014, http://www.besticity.com/place/77910.html.

[83] "Hangzhou People's Government Office Notice on Issuing 'Digital Hangzhou' ('New-Style Smart Hangzhou' First Period) Development Plan (杭州市人民政府办公厅关于印发"数字杭州"("新型智慧杭州"一期)发展规划的通知)," August 14, 2017, http://www.besticity.com/place/241757.html.

City Development, 2017 (菏泽市人民政府关于加强智慧城市建设的意见)[84]	**City management**: Innovative management models, enhanced administrative efficiency; improve smart city program organizational leadership, decision-making, and market incentives. **Economic development**: Apply information technologies to make manufacturing smarter, encourage international commerce, move towards higher-end products, encourage innovation, develop smart industry parks, promote smart industries including big data, cloud computing, IoT, AI, electronics, and information consumption industries.

Planning documents like the ones cited in the table above condense a variety of major components of smart city plans into digestible priorities for city officials, but they are not necessarily a comprehensive outlook on all development areas, comparative priorities, or even implementation status in their respective localities. Any assessment or comparison of these aspects of smart city development in China would be based upon different levels of pre-existing economic development and provincial resources, rendering accurate comparison between these cities difficult at best. Some qualitative insights can be gleaned from planning information and existing context: for instance, Hangzhou does seem to have focused on artificial intelligence (AI) more than other cities, in part due to a close working relationship with Alibaba. Even these insights, however, are not necessarily derived from any concrete assessment of how complete implementation is: few plans, like the Smart Shenzhen program described below, have ironclad completion deadlines or assessment mechanisms in spite of detailed lists of development priorities.

Example: Smart Shenzhen

As is evident from Table 3, Chinese smart cities plans and guidelines are often broad in scope with few concrete timelines. In some cases, plans appear to be light on detail and may serve mainly to authorize local agencies to explore initiatives within the scope of their departmental mandates. Central government funding dynamics encourage municipal policymakers to reach widely when identifying smart cities goals. For example, MOHURD rules for smart city pilot project accreditation require that city governments must have a smart city development plan in place prior to applying for funding.[85] Even detailed plans make only vague reference to a timeline for completion: Shenzhen's *2018 New-Style Smart City Development Plan*, for instance, only lists 2020 as a target for the completion of several initiatives included in the plan itself.[86]

Still, the level of detail provided by some city plans is sufficient to demonstrate serious commitment to smart city services and systems. The same Shenzhen *2018 New-Style Smart City Development Plan*, for example, builds on several prior "Smart Shenzhen" planning documents and reflects a mature vision for using ICT to enhance public services, city management, and economic development in specific ways.[87] Table 4 summarizes specific smart city initiatives listed

[84] "Heze People's Government Opinion on Strengthening Smart City Development (菏泽市人民政府关于加强智慧城市建设的意见)," Heze People's Government (菏泽市人民政府), November 1, 2017, http://www.besticity.com/place/175496.html on 18 July 2019.

[85] "[National Smart City Pilot Project Temporary Management Methods] (国家智慧城市试点暂行管理办法)," Ministry of Housing and Urban-Rural Development of the People's Republic of China, November 22, 2012, http://www.mohurd.gov.cn/wjfb/201212/t20121204_212182.html.

[86] "Shenzhen People's Government Notice on Issuing New-Style Smart City Development Plan (深圳市人民政府关于印发新型智慧城市建设总体方案的通知)," Shenzhen People's Government General Office, July 30, 2018, http://www.besticity.com/place/232256.html.

[87] Earlier smart city plans issued by Shenzhen include "Smart Shenzhen Planning Outline (2011-2020)" (《智慧深圳规划纲要(2011-2020 年)》), "Smart Shenzhen Development Implementation Plan (2013-2015)" (智慧深圳建设

in Shenzhen's 2018 plan, including projects related to public services (healthcare, education, community, and weather), city management (public safety, operations management, transportation, and water management) and economic development (industry, digital economy, and smart industry parks). While the document did not identify specific funding sources for this effort, it describes a competitive funding environment in which city officials were to attract private capital investment and expand the establishment of separate levels of investment mechanisms to obtain national and provincial level funding.[88]

Among the plan's projects supporting public services, commonalities include using the internet to establish public-facing information resources and interactive services and sharing existing data resources between institutions to improve coordination and service quality. Among initiatives related to city management, themes include enhancing information sharing between organizations and departments, and using IoT-connected devices such as surveillance cameras, smart streetlights, water sensors, and port security equipment to improve situational awareness and enhance efficiency. Within the plan's content related to economic development, projects aim to promote integration between online and offline economic activity, use online platforms to share social data resources, and ensure availability of ICT infrastructure to support businesses. Across all three application areas, data collection, management, analysis, and sharing are at the heart of all of Shenzhen's smart city efforts, reflecting continuity between China's smart cities initiatives and other national informatization programs.

Table 4: Example Smart City Projects Identified in Shenzhen's 2018 New Style Smart City Development Plan[89]

Public Services
Healthcare: Set up regional health and family planning information platforms and data centers; set up information-sharing mechanisms linking public health and medical institutions; set up a city-wide resident healthcare services portal to provide online consultation, appointment-booking, diagnosis, and hospital admittance services; promote the establishment of online hospitals and smart community clinics.
Education: Set up cloud service platforms for schools and society, including databases with model classroom curricula; explore cloud-based market spaces for digital education resources; offer multimedia classrooms to 95 percent of elementary- and middle-school students; connect 90 percent of primary and second schoolers with online study spaces.

实施方案(2013—2015 年)), and "Shenzhen New-Style Smart City Development Plan (2016-2020]" (《深圳市新型智慧城市建设工作方案(2016-2020 年)》). See also: "[Notice from the General Office of the Shenzhen Municipal People's Government on Printing and Distributing the Implementation Plan for Smart Shenzhen Construction (2013-2015)] (深圳市人民政府办公厅关于印发智慧深圳建设实施方案(2013—2015 年)的通知)," Shenzhen Municipal People's Government, August 12, 2017, http://www.besticity.com/place/73115.html; "[Case Study: Lin Yi: Shenzhen – Building A New National Smart City] (案例分享| 林毅:深圳——建设国家新型智慧城市)," Shenzhen Economic and Information Committee, November 30, 2017, http://www.besticity.com/info/192960.

[88] "Shenzhen People's Government Notice on Issuing New-Style Smart City Development Plan (深圳市人民政府关于印发新型智慧城市建设总体方案的通知)," Shenzhen People's Government General Office, July 30, 2018, http://www.besticity.com/place/232256.html.

[89] See "Shenzhen People's Government Notice on Issuing New-Style Smart City Development Plan (深圳市人民政府关于印发新型智慧城市建设总体方案的通知)," Shenzhen People's Government General Office, July 30, 2018, http://www.besticity.com/place/232256.html.

Community: Set up community feedback communications channels and encourage residents to participate in governance; set up assistance platforms to help handicapped and elderly residents obtain resources; set up legal services platforms to provide public services and encourage local business entrepreneurship. **Weather**: Upgrade the Shenzhen Weather app and WeChat account[90] to provide personalized weather services.
City Management
Public safety: Set up smart public safety systems covering public security, production safety, food and drug safety, and geological safety hazards; build city-wide public surveillance systems and a third-generation public security command center with full-area surveillance coverage, full network sharing, fully controllable processes, and 24/7 usability; increase the use of information related to social stability, terrorism, crime-fighting, and public security; develop smart port management systems including intelligent infrared sensing equipment, nuclear detection vehicles, UAVs, and robotic inspection equipment. **Operations management**: Establish a smart city operations management center with functions for displaying city operational status information, coordinating public services, and supporting decision-making; set up a government management command center to integrate city information resources with resources from public service organization and internet, enterprise, and telecommunications operators, to provide real-time city-wide situational awareness; bolster data sharing and communications between management and public security command centers. **Transportation**: Establish a comprehensively-managed, low-carbon green transportation system; upgrade transportation ICT; promote the use of adaptive streetlights, parking sensors, digital display screens, and video resources; establish an integrated transportation management center; promote the aggregation and sharing of traffic, public security, and weather information; aggregate city-wide parking lot information and promote smart parking to increase utilization rates; initiate autonomous vehicle demonstration and testing projects and accelerate the use of AI for driverless vehicles to make such vehicles safer. **Water management**: Promote sharing of water volume and quality information and GIS and video surveillance data related to water pipe networks; set up a city-wide "smart sponge" platform to improve capabilities for water management; implement real-time monitoring of important sewage discharge points.
Economic Development
Industry: Promote integration between internet and industry at the design, manufacturing, and logistics stages; encourage internet-based design practices including resource sharing, internet-based design collaboration, crowd-sourcing, and online 3D printing services; promote internet-coordinated manufacturing, customization, and manufacturing-as-a-service; set up smart manufacturing demonstration projects. **Digital economy**: Promote the sharing of government and other public data to encourage the development of value-added innovations; establish big data exchanges to promote resource sharing; set up a smart city open source data innovation service platform to promote the use of social data resources. **Smart industry parks**: Ensure availability of fiber-optic broadband, next-generation wireless, and free Wi-Fi infrastructure; encourage parks to offer cloud services to enterprises based on park-operated cloud platforms.

While the Shenzhen program is slated to run until 2020 and is therefore not subject to a full governmental evaluation of its progress until that time, preliminary indications suggest that Shenzhen's smart city implementation efforts lead the country. A 2018 assessment report of Chinese smart city development issued by the Chinese Academy of Social Sciences rated Shenzhen's smart city development standard as the highest in China.[91] While it is unclear if these assessments directly account for the effects of the Shenzhen smart cities plan or even its pre-

[90] WeChat is an increasingly ubiquitous multi-functional mobile application popular in China, incorporating messaging, mobile payment, online shopping, and a variety of other functions into one mobile application. See Arjun Kharpal, "Everything You Need to Know About WeChat – China's Billion-User Messaging App," CNBC, February 3, 2019, https://www.cnbc.com/2019/02/04/what-is-wechat-china-biggest-messaging-app.html.

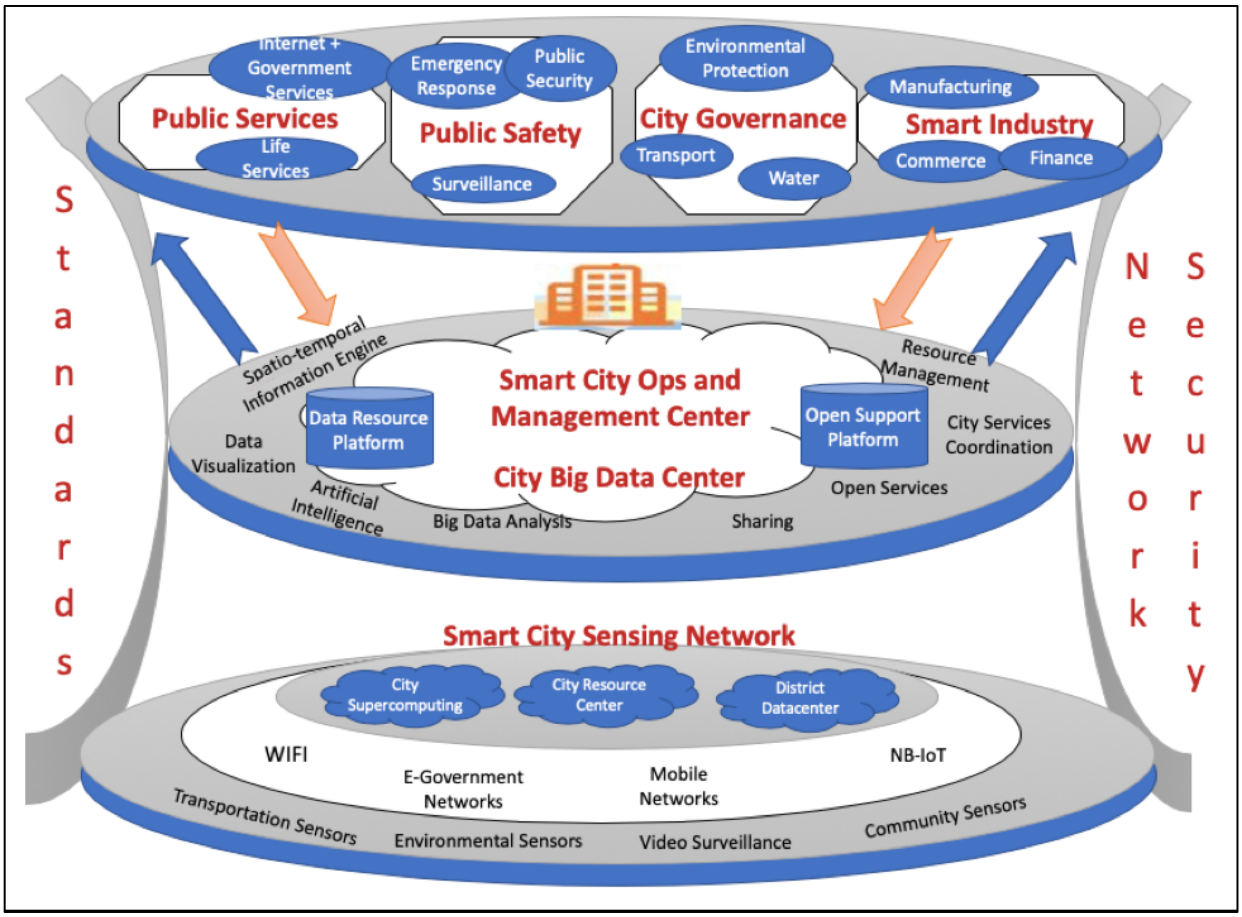
[91] Chen Hai 陈海, "[Ping'an, Tencent, and Huawei Endow Capabilities: Shenzhen Smart City Development Standard Ranked First in the Nation] (平安腾讯华为科技赋能：深圳智慧城市发展水平居全国第一)," Xinhua, December 7, 2018, http://www.xinhuanet.com/money/2018-12/07/c_1210011297.htm.

existing strengths as a hub of China's information economy, it is clear that local and national officials regard Shenzhen as a shining example of smart city development in China.

Growth in Key Technologies: The IoT, Big Data, and the Cloud

A small number of information and communications technologies (ICT) are repeatedly identified as key enablers of Chinese smart cities projects, including the IoT, big data, and cloud computing.[92] Somewhat less consistently, mobile internet access and artificial intelligence (AI) are also mentioned as important underlying technologies.[93] Figure 3, taken from Shenzhen's 2018 smart city development plan, illustrates the foundational role that these technologies are expected to play in supporting smart city services.

Figure 3: Shenzhen's Smart City Development Plans



[92] See "Shanghai Action Plan to Promote Smart City Development (2014-2016) (上海市推进智慧城市建设行动计划[2014-2016])," Shanghai Economic and Informatization Commission (上海经济和信息化委员会), December 17, 2014, http://www.besticity.com/place/77910.html; "Hangzhou People's Government Office Notice on Issuing 'Digital Hangzhou' ('New-Style Smart Hangzhou' First Period) Development Plan (杭州市人民政府办公厅关于印发"数字杭州"("新型智慧杭州"一期)发展规划的通知)," August 14, 2017, http://www.besticity.com/place/241757.html; "Heze People's Government Opinion on Strengthening Smart City Development (菏泽市人民政府关于加强智慧城市建设的意见)," Heze People's Government (菏泽市人民政府), November 1, 2017, http://www.besticity.com/place/175496.html.

[93] Ibid.

Source: Shenzhen People's Government General Office.[94]

In Figure 3, the IoT, mobile internet, and cloud computing are identified as essential components of Shenzhen's smart city sensing network. This is true in other cities as well. Chinese planners envision using IoT networks, specifically narrowband IoT (NB-IoT) 5G cellular networks,[95] to collect data from vast numbers of smart sensors deployed throughout cities and transfer it to remote cloud computing platforms for storage and analysis. Public-facing online platforms delivered via mobile internet provide interfaces to enable users to access services and provide data. As shown in the figure's middle layer, by applying big data analysis techniques to cloud-hosted data, city administrators can maintain situational awareness and gain insight into key urban indicators to complete a wide range of management functions with improved efficiency, from environmental monitoring and infrastructure maintenance to transportation system optimization and public security surveillance. In some cases, smart cities systems may incorporate AI algorithms and responsive IoT devices such as smart traffic signals, surveillance cameras, and streetlights to deliver services autonomously without human operators. Table 5 provides additional illustrative examples of smart cities applications for key enabling technologies.

Table 5: Example Applications of Key Smart City Technologies

Technology	Example Smart City Applications
Internet of Things	Networked video cameras; sensors and actuators supporting street and traffic light automation, smart waste management, water, gas, and electrical infrastructure monitoring, environmental quality monitoring; smart electrical metering; smart manufacturing upgrades.
Big data	Social credit information platforms; traffic signal optimization; spatio-temporal GIS information platforms; police and fire incident analysis.
Cloud computing	Video surveillance data storage; cloud-based storage and processing of IoT sensor data; city- and district-level government data storage and computing centers; public cloud centers for business parks.
Mobile internet	E-government services; smart tourism services; community legal services; weather information; cashless payments.
Artificial intelligence	Smart surveillance cameras, streetlights, parking, and public transportation systems; maintenance scheduling for smart infrastructure & smart manufacturing.

There are indications that China is making significant progress in developing and deploying the ICT required to support smart cities projects, laying a firm foundation for future growth. Statistics from the MIIT and other Chinese government agencies show that several industries that China's

[94] See "Shenzhen People's Government Notice on Issuing New-Style Smart City Development Plan (深圳市人民政府关于印发新型智慧城市建设总体方案的通知)," Shenzhen People's Government General Office, July 30, 2018, http://www.besticity.com/place/232256.html.

[95] Generally speaking, narrowband IoT infrastructure allows for significantly lower power and bandwidth requirements for devices connected to these networks. Perhaps more importantly, however, the Chinese government's emphasis on NB-IoT is an exemplar of its overall strategy that attempts to leverage first-to-market status into overall global compliance with Chinese equipment standards. See John Chen, Emily Walz, Brian Lafferty, Joe McReynolds, Kieran Green, Jonathan Ray, and James Mulvenon, "China's Internet of Things," Research Report Prepared on behalf of the U.S.-China Economic and Security Review Commission, October 2018, 90-91, https://www.uscc.gov/sites/default/files/SOSi_China%27s%20Internet%20of%20Things_Executive%20Summary.pdf.

leaders regard as critical component building blocks of smart cities[96] are expanding rapidly, including China's IoT, big data, and cloud computing industries.

- **Internet of Things**: China's IoT industry has grown from approximately RMB 200 billion ($28.0 billion) in 2010, shortly after IoT was identified as a core development priority, to nearly RMB 1.5 trillion ($209.8 billion) in 2018, according to a 2018 report from the China Economic Information Service.[97] MIIT also reported that IoT revenues increased by 73 percent year-on-year in 2018.[98]
- **Big data:** Core industries in the big data sector are projected to grow by at least 25 percent to reach RMB 720 billion ($100.7 billion) in 2019, according to a report from China Electronic Information Industry Development (CCID), a think tank affiliated with MIIT. Big data sales revenues are projected to reach RMB 1 trillion ($139.9 billion) by 2020, under a 2017 MIIT development plan.[99]
- **Cloud services**: China's public cloud market reached RMB 43.7 billion ($6.1 billion) in 2018, an increase of 65.2 percent year-on-year, according to a white paper from the China Academy of Information and Communications Technology (CAICT), another MIIT research institute. CAICT projects that the market will nearly quadruple to reach RMB 173.1 billion ($24.2 billion) by 2022.[100]

While market growth statistics for ICT industries that support smart city industries are one crude measure of smart city development, evidence suggests that market growth is augmented by large-scale investment and deployment of technologies that are viewed as crucial for smart city development. Regarding NB-IoT networks specifically, China's major telecommunications operators are rolling out the technology to hundreds of thousands of cellular base stations, in accordance with MIIT guidance calling for nationwide coverage via 1.5 million NB-IoT-enabled base stations by 2020.[101] China Telecom had upgraded at least 310,000 base stations for NB-IoT by early 2018, while China Mobile planned to build more than 400,000 NB-IoT base stations in 2017 and 2018. [102] All three providers also offer integrated solutions to support specific smart city use cases centered on NB-IoT. For example, China Unicom has developed a smart sewage drain cover solution to provide real-time information on the location, orientation, and operating

[96] Jin Jiangjun 金江军, ed., *Leading Cadre Reader for Network Security and Informatization (网络安全和信息化党政领导干部读本)* (Beijing: Central Committee Party School Press, 2017), 21.
[97] "How China is Scaling the Internet of Things," GSMA Connected Living Programme, July 2015, 4, https://www.gsma.com/newsroom/wp-content/uploads/16531-China-IoT-Report-LR.pdf. See also "China Expected to See Rapid IoT Market Growth," China Daily, modified September 15, 2018, http://www.chinadaily.com.cn/a/201809/15/WS5b9c4e39a31033b4f4656317.html.
[98] "China's IoT Revenue Soaring," Xinhua, modified March 26, 2019, http://www.chinadaily.com.cn/a/201903/26/WS5c99e245a3104842260b2aa3.html.
[99] "China's Big Data Sector to Expand Rapidly in 2019," Xinhua, modified February 14, 2019, http://www.chinadaily.com.cn/a/201902/14/WS5c652ef6a3106c65c34e95f1.html.
[100] "China's Cloud Computing Market Close to $14b," Xinhua, modified July 8, 2019, http://www.chinadaily.com.cn/a/201907/08/WS5d22fe5ea3105895c2e7c4c2.html.
[101] Tom Rebbeck, "China Will Lead the World in NB-IoT, Which Will Benefit Chinese Vendors and the Ecosystem Worldwide," Analysys Mason, January 18, 2018, https://www.analysysmason.com/Research/Content/Comments/China-IoT-benefits-RDME0-RDRP0/.
[102] Tom Rebbeck, "China Will Lead the World in NB-IoT, Which Will Benefit Chinese Vendors and the Ecosystem Worldwide," Analysys Mason, January 18, 2018, https://www.analysysmason.com/Research/Content/Comments/China-IoT-benefits-RDME0-RDRP0/.

condition of drain covers. The company also offers end-to-end NB-IoT solutions for smart streetlighting and electrical metering.[103]

With respect to artificial intelligence, Chinese AI companies have benefitted from strong national government interest in developing AI as a strategic industry and appear well-positioned to provide support for smart cities programs. Under a "New Generation Artificial Intelligence Development Plan" (新一代人工智能发展规划) announced by the State Council in 2017, China has set ambitious growth targets for its AI industry—including developing a RMB 1 trillion ($139.9 billion) domestic AI industry to become the world leader in AI by 2030.[104] Chinese computer vision companies such as SenseTime, Megvii, CloudWalk, and Intellifusion have developed world-leading algorithms for facial recognition, gait recognition, and vehicle and person identification, and applied them widely within China's public security surveillance market. To help address concerns that a shortage of high-end AI talent may limit progress in the future, more than 30 Chinese universities have established AI colleges under the guidance of China's Ministry of Education, and 35 universities will offer an undergraduate AI major starting in Fall 2019.[105] Taken together, both market growth and anecdotal indicators suggest that the development of Chinese smart cities is accelerating through market growth, deployment progress, and educational prioritization of critical underlying industries related to smart cities.

Coordinating Governance and Management: Leading Small Groups and Big Data Management Administrations, and National and International Connections

Leading Chinese smart cities experts have identified data sharing and coordination across agencies as critical challenges for smart cities growth. To help resolve these potential bottlenecks at the municipal level, cities across China have established interdepartmental leading small groups that are responsible for managing smart city initiatives within their jurisdictions, and can also maintain contact with relevant experts and participate in top-level planning.[106] For example, the city of Qingdao's Smart City Development Leading Small Group (青岛市智慧城市建设领导小组), established in February 2013, is led by the city's mayor and includes representatives from the city's development and reform commission, economic and informatization committee, and numerous other administrative units including the city's education, science and technology, and public security bureaus.[107] Similarly, the prefecture-level city of Panzhihua in Sichuan province established a Smart City Development Leading Small Group in 2017 under the leadership of the city's mayor, which is intended to "accelerate the integration of the city's data resources and

[103] Chen Xinjie and Yang Yang, "Smart Applications Proliferate: China Mobile IoT Report Series Product Application Article (智慧遍万家 应用广生花 中国联通物联网系列报道之产品应用篇)," September 13, 2017, http://www.cnii.com.cn/telecom/2017-09/13/content_1888574.htm.

[104] "State Council Notice on Issuing New Generation Artificial Intelligence Development Plan (国务院关于印发新一代人工智能发展规划的通知)," PRC State Council, July 20, 2017, http://www.gov.cn/zhengce/content/2017-07/20/content_5211996.htm.

[105] Yi-Ling Liu, "China's AI Dreams Aren't for Everyone," *Foreign Policy*, August 13, 2019, https://foreignpolicy.com/2019/08/13/china-artificial-intelligence-dreams-arent-for-everyone-data-privacy-economic-inequality/.

[106] "Shenzhen New-Style Smart City Development Leading Small Group Holds First Meeting (深圳市新型智慧城市建设领导小组第一次会议召开)," *Shenzhen Special Zone Daily (深圳特区报)*, modified November 9, 2016, http://www.sz.gov.cn/cn/xxgk/zfxxgj/sldzc/szfld/cb/jqhd/201611/t20161109_5265003.htm.

[107] "Notice Regarding the Establishment of Qingdao Smart City Development Leading Small Group (关于成立青岛市智慧城市建设领导小组的通知)," Qingdao People's Government Office (青岛市人民政府办公厅), February 10, 2013, http://www.besticity.com/place/73039.html.

promote smart city development and big data industry development."[108] Smart city leading small groups have also been formed at the district government level when necessary to coordinate major projects.[109] For example, the Chengdu Hi-Tech Industrial Development Zone established a smart city leading small group (成都高新区智慧城市建设领导小组) in 2019 to support high-level planning, resource and information sharing, and critical project work.[110] At the provincial level, several provinces (including Hunan, Liaoning, Hainan, Shandong, Jiangsu, and Guangdong) have established Big Data Management Administrations (大数据管理局) to support big data and smart city initiatives within their respective jurisdictions.[111]

Beyond municipal and provincial administrative bodies for smart cities projects within their jurisdictions, organizational mechanisms for coordinating smart city development across localities are less clear. It is likely that ministries such as MOHURD and MIIT play a role in setting smart city standards and promoting best practices as an aspect of their involvement in project certification and sponsorship, but their exact role in enforcing information- and standards-sharing is unknown.[112] Several national-level organizations have also been formed to exchange information between smart city industry participants, promote industry standards, and encourage development, including the China Strategic Alliance of Smart City Industrial and Technology Innovation (中国智慧城市产业技术创新战略联盟) established by MOST in 2012, the China Smart City Industry Alliance (中国智慧城市产业联盟) set up by MIIT in 2013, and a National Standardization General Working Group on Smart Cities (国家智慧城市标准化协调推进组) initiated by the NDRC, MOST, MIIT, and MOHURD in 2014.[113] Commercial enterprises providing smart cities products and services to multiple city governments also likely play an important role in cross-pollination between smart cities projects in different areas.

Internationally, many Chinese cities have been involved in exchange programs, conference events, and cooperative pilot projects aimed at sharing smart city ideas and experiences with foreign city administrators. For example, in June 2019, MOHURD and the district government of Shanghai's Pudong New Area sponsored the 2019 Smart City International BBS Shanghai Forum, which

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[108] "Notice Regarding the Establishment of Panzhihua Smart City Development Leading Small Group (关于成立攀枝花智慧城市建设领导小组的通知)," Panzhihua People's Government Office (攀枝花市政府办公室), May 3, 2017, http://www.besticity.com/place/73132.html.

[109] Districts (区) are administrative divisions under large cities and directly-administered municipalities, while prefectures (州) are administrative divisions under provinces and autonomous regions. See "[Administrative Divisions of the People's Republic of China] ("中华人民共和国行政区划"), Chinese Government Network (中国政府门户网站), June 2005, http://www.gov.cn/test/2005-06/15/content_18253.htm.

[110] "Chengdu High and New Technology Zone Smart City Development Leading Small Group First Work Promotion Meeting Held to Upgrade Smart City Development Capabilities and Levels (成都高新区智慧城市建设领导小组第一次工作推进会召开 全面提升智慧城市建设能力和水平)," Chengdu High and New Technology Zone Multimedia Center (成都高新区融媒体中心), modified June 21, 2019, http://www.chinahightech.com/html/gaoxinqu/cdgxq/cyjj/2019/0621/531440.html.

[111] "Why are Local Governments Establishing Big Data Management Administrations (地方为何纷纷设立大数据管理局)," *Beijing News (新京报)*, modified October 19, 2018, http://www.xinhuanet.com/comments/2018-10/19/c_1123580947.htm.

[112] The extent to which these government bureaucracies actually enforce standards and information sharing is likely directly related to the degree of competition that exists between the smart city initiatives of various localities, although information on these competitive dynamics is difficult to obtain in available open source materials.

[113] "China Strategic Alliance of Smart City Industrial and Technology Innovation," 2015, http://www.cscity.org.cn/index.php?m=content&c=index&a=lists&catid=2.

brought together representatives for the city governments of Hefei, Shenyang, Chengdu, Huoshan, Wenchuan, and Foshan, and current and former government officials from Japan, Singapore, Portugal, and France. Discussion topics included energy conservation, smart tourism, smart city upgrades for industrial cities, sustainable development, 5G infrastructure, international standardization, AI, cross-border payments, and comparing Chinese and European smart cities.[114]

Chinese cities have also formed city-level smart cities partnerships with foreign cities and towns, such as relationships between Bristol (UK) and Guangzhou,[115] Manchester (UK) and Wuhan,[116] and Paris and Beijing.[117] At the national level, China has also signed a number of strategic smart cities partnership agreements, including a UK-China Smart City Memorandum of Understanding, Memorandum of Germany-China Smart City Cooperation, U.S.-China Smart City Cooperation Framework Agreement, and a Joint Statement Between the People's Republic of China and the Republic of India on Launching Smart City Cooperation.[118] These partnerships appear to be oriented mainly towards knowledge-sharing and trade opportunities, rather than data sharing or transfers of specific technologies. For example, the Beijing-Paris agreement calls for funding a joint research lab named City of the Future, while Richard Leese, leader of the Manchester City Council, called the Wuhan-Manchester agreement a chance to identify shared ambitions, respective strengths, and trade and business opportunities.[119] For further discussion of China's promotion of its smart cities technologies abroad, see Chapter 4 of this report.

Commercial Enterprise Involvement

China's smart cities initiatives are supported by a robust domestic ecosystem of commercial ICT enterprises. While foreign firms such as IBM and Cisco reportedly played a significant role in introducing smart cities concepts to China, and international companies such as Microsoft, Amazon, Deloitte, and Bosch continue to provide technology and consulting services, Chinese companies are currently the dominant players in China's smart cities market.[120]

A 2018 list of top Chinese e-government and smart cities solutions providers from Chinese industry research firm Qianzhan Industry Research Institute includes well-known technology brands such as Huawei, ZTE, Inspur, and Lenovo alongside state-owned telecommunications

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[114] "2019 International Smart City Expo – Shanghai Pudong," MWC Shanghai, https://www.mwcshanghai.com/exhibition/smart-city-expo/.

[115] "Bristol is Open Announces its First Partnerships," University of Bristol News, March 16, 2015, https://www.bristol.ac.uk/news/2015/march/bristol-is-open.html.

[116] "Wuhan, Manchester to Deepen Cooperation in Urban Development," Xinhua, February 27, 2018, http://www.xinhuanet.com/english/2018-02/27/c_137003983.htm.

[117] "Paris and Beijing Sign Partnership Agreement on AI and Smart Cities," Smart Cities World Forums, June 20, 2018, http://www.smartcitiesworldforums.com/news/smart-cities-europe/finance-policy-eu/922-paris-and-beijing-sign-partnership-agreement-on-ai-and-smart-cities.

[118] Cui Ying, "Development and Practice of Smart City in China," CAICT Industry and Planning Research Institute, November 3, 2017, https://www.itu.int/en/ITU-D/Regional-Presence/AsiaPacific/SiteAssets/Pages/Events/2017/Oct2017CIIOT/CIIOT/15.Session5-5%20Development%20and%20Practice%20of%20Smart%20City%20in%20China-%E5%B4%94%E9%A2%96V2red.pdf.

[119] "Paris and Beijing Sign Partnership Agreement on AI and Smart Cities," Smart Cities World Forums, June 20, 2018, http://www.smartcitiesworldforums.com/news/smart-cities-europe/finance-policy-eu/922-paris-and-beijing-sign-partnership-agreement-on-ai-and-smart-cities; "Wuhan, Manchester to Deepen Cooperation in Urban Development," Xinhua, February 27, 2018, http://www.xinhuanet.com/english/2018-02/27/c_137003983.htm.

[120] Christina Nelson, "Smart City Development in China," *China Business Review*, modified June 17, 2014, https://www.chinabusinessreview.com/smart-city-development-in-china.

giants China Telecom, China Unicom, and China Mobile.[121] Internet companies such as Baidu, Alibaba, and Tencent have also made inroads based on their experience with AI, big data, and cloud computing technologies; their mobile user bases; and their vast reserves of Chinese consumer data.[122] Other market leaders include cloud solutions providers such as Alibaba Cloud and supercomputer developer Sugon, AI firms such as voice recognition provider iFlyTek, and surveillance specialists such as Hikvision and Dahua Technology.[123] Table 6 provides examples of leading enterprises within several technology sectors.

Table 6: Leading Chinese Enterprises in Key Smart City Technology Domains

Technology	Leading Enterprises
Internet of Things & mobile infrastructure	Huawei, China Mobile, Inspur, China Unicom, Tencent, ZTE, H3C, Sugon, Alibaba Cloud, Hikvision, Dahua[124]
Big data	Neusoft, Tencent, Huawei, Inspur, Beiming Software, H3C, Sugon, Taiji, Digital China, Alibaba Cloud[125]
Cloud computing	Sugon, Alibaba Cloud, Tencent Cloud, Huawei, UCloud, China Telecom, Amazon Web Services, Kingsoft, Microsoft Azure, Baidu Cloud[126]
Artificial intelligence	Alibaba, Baidu, Tencent, iFlyTek, Huawei, SenseTime, Megvii, Intellifusion, CloudWalk, Yitu, Hikvision, Dahua[127]

China's defense conglomerates have also leveraged their experience as systems integrators to participate in China's smart city market. The state-owned defense electronics conglomerate China Electronics Technology Group Co., Ltd. (CETC) established its own Smart City Research Institute (中电科新型智慧城市研究院有限公司) in April 2016, and has since partnered with city governments in Shenzhen, Fuzhou, and Jiaxing to design and implement model smart cities in

[121] "2019 Market Layout: Outlook on 2019 China Smart City Development Competitive Landscape (Including Market Share, Enterprise Comparison, Competitive Prospects) (2019 市场格局:《2019 年中国智慧城市建设竞争格局全局观》(附市场份额、企业经营对比、竞争前景))," Qianzhan Industry Research Institute, modified June 19, 2019, https://www.qianzhan.com/analyst/detail/220/190618-4ce4b615.html.

[122] "BAT in Smart Cities – After Alibaba and Tencent, Shanghai Welcomes Baidu (智慧城市里的 BAT——继阿里和腾讯之后，上海迎来百度)," Leiphone.com (雷锋网), modified November 28, 2018, http://tech.ifeng.com/a/20181127/45239217_0.shtml?tp=1544371200000.

[123] "2019 Market Layout: Outlook on 2019 China Smart City Development Competitive Landscape (Including Market Share, Enterprise Comparison, Competitive Prospects)" (2019 市场格局：《2019 年中国智慧城市建设竞争格局全局观》（附市场份额、企业经营对比、竞争前景）), Qianzhan Industry Research Institute, modified June 19, 2019, https://www.qianzhan.com/analyst/detail/220/190618-4ce4b615.html.

[124] "Who are the Strongest Players in China's Smart City Market? (谁是中国智慧城市最强玩家？)," Guomai Smart City Network (国脉智慧城市网), modified August 10, 2018, http://www.besticity.com/newsExpress/225005.html.

[125] "Who are the Strongest Players in China's Smart City Market? (谁是中国智慧城市最强玩家？)," Guomai Smart City Network (国脉智慧城市网), modified August 10, 2018, http://www.besticity.com/newsExpress/225005.html.

[126] "Alibaba Cloud Owns 43% China's Public Cloud Market in 2018," China Internet Watch, February 12, 2019, https://www.chinainternetwatch.com/28150/public-cloud-h1-2018/.

[127] "2019 Market Layout: Outlook on 2019 China Smart City Development Competitive Landscape (Including Market Share, Enterprise Comparison, Competitive Prospects)" (2019 市场格局：《2019 年中国智慧城市建设竞争格局全局观》（附市场份额、企业经营对比、竞争前景）), Qianzhan Industry Research Institute, modified June 19, 2019, https://www.qianzhan.com/analyst/detail/220/190618-4ce4b615.html.

these municipalities,[128] designing and integrating smart police services, law enforcement, and governance platforms with other smart city infrastructure.[129] Similarly, in Tibet, the Lhasa municipal government has formed a joint venture with CETC to manage core aspects of its latest "new model smart city" development program.[130] CETC's 54th Research Institute, a major supplier of military communication systems to the People's Liberation Army (PLA), has reportedly taken a leading role in designing Lhasa's overall smart city architecture.[131]

In addition to CETC, state-owned aerospace defense conglomerates China Aerospace Science and Industry Corporation, Ltd. (CASIC) and China Aerospace Science and Technology Corporation (CASC) have also developed smart cities business lines. CASIC, for instance, has designed smart cities concepts that include smart public security, transportation, and governance programs for more than twenty Chinese cities, including Wuhan, Hangzhou, Shenyang, and Shaoxing, and CASC established a dedicated smart cities subsidiary—Shenzhen Aerospace Smart City System Technology Co., Ltd. (深圳航天智慧城市系统技术研究院有限公司)—in 2016.[132]

While not all of these companies are necessarily state-owned, many of them are, and those that are not state-owned nevertheless boast close ties to the governing apparatus. Many of these companies have used close relationships with local and central development initiatives to help develop smart cities technologies, and many of them are some of the largest companies in the world in their respective areas of technical expertise. Taken together, these formal and informal members of the "national team (国家队)"[133] represent some of the Party's most successful attempts to use private means to develop economic strength in information and communications technology by allowing these firms to dominate in a large, domestic smart city market.

Successes to Date, Challenges Ahead

On the whole, China has made considerable progress in implementing smart city solutions to improve city management and better the lives of Chinese urban residents. As of November 2018, 100 percent of Chinese cities at the vice-provincial level and 90 percent of prefecture-level cities (more than 700 cities in total) had either put forward smart city development plans or were in the

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[128] "About Us: Company Profile," The Smart City Research Institute of China Electronics Technology Group Corporation (中电科新型智慧城市研究院有限公司), http://www.cetccity.com/about-us/company-profile.

[129] "Smart Jiaxing" CETC Aids Construction of New Nameplate for City ("智慧嘉兴" 中国电科助力建设城市新名片)," CETC 5th Annual Internet Conference Report, November 11, 2018, http://www.cetc.com.cn/zgdzkj/_300931/_300943/zgdkdwjhldhztbd/dkfa/1517019/index.html.

[130] "CETC Xueyu Information Industry Co., Ltd. (中电雪域信息产业有限公司)," Zhaopin.com, https://company.zhaopin.com/CZ896136310.htm.

[131] "Lhasa is Building a New-Style Smart City! (拉萨市要建"新型智慧城市"啦！)," Lhasa Chengguan District Tourism Bureau (拉萨市城关区旅游局), modified December 20, 2017, https://www.sohu.com/a/211687574_99958214; "Implementation of Additional Changes from the Annual Review of the Entity List," Department of Commerce Bureau of Industry and Security, December 17, 2010, https://www.strtrade.com/media/publication/4572_2010-December-17-bis_entity_list.pdf.

[132] Hu Yang, "CASIC Helps Chinese Cities Get Smart," *China Daily*, modified November 14, 2012, http://www.chinadaily.com.cn/business/greenchina/2012-11/14/content_15927027.htm.

[133] One prominent instantiation of a "smart cities national team" is the Chinese Academy of Sciences Smart City Industry Alliance (中国科学院智慧城市产业联盟), which includes Sugon and a variety of other research institutes and companies in an effort to share information and resources via strategic partnerships to raise the overall competitive ability of Chinese smart city manufacturers. See Liu Yan, "Chinese Academy of Sciences Smart City Industry Alliance Established (中国科学院智慧城市产业联盟)," *Science and Technology Daily,* July 7, 2017, http://www.cac.gov.cn/2017-07/07/c_1121278673.htm.

process of building smart city projects, according to Xu Zhenqiang, deputy director of the Digital City Center at the China Urban Science Research Association.[134]

Recent examples of successful smart city projects in major Chinese cities abound. For example:

- Hangzhou's "City Brain" platform, initially developed by Alibaba in 2016,[135] now uses AI algorithms to manage more than 1,000 road signals around the city, shortening commutes, detecting potential traffic accidents, and improving emergency response times by up to 49 percent.[136] The city was previously ranked the fifth most-congested city in China but has fallen to 57th since the system was launched.[137]
- On December 1, 2016, the Shanghai municipal government began offering streamlined government services for residents through a Citizen Cloud platform accessed by mobile app. The platform includes more than 100 government services, including drivers' license details, health records, and local services.[138]
- Beginning in 2010, Guangzhou launched a regional health information platform to store electronic health records for residents and link municipal hospitals and clinics.[139] The program has stored more than eight million electronic health records and linked ten local hospitals and clinics since its initiation. Guangzhou hospitals also offer patient services through an integrated smart medical app, enabling citizens to book appointments, pay hospital fees, and arrange for home delivery of prescription drugs all from their smart phones.[140]
- In Shenzhen, transportation managers have deployed AI and big data technologies to improve road safety. As of June 2018, the city's roadway surveillance network incorporates computer vision technologies capable of identifying images of traffic violators with 95 percent accuracy.[141]

Despite these signs of progress, challenges loom on the horizon. First, the primary bottlenecks for future smart cities growth may be as much institutional as technological. As China Smart City

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[134] Sina News, "Xu Zhenqiang – Smart City Development Requires 'Micro Intelligence' (徐振强丨智慧城市建设需要"微智慧落地")," Besticity.com, January 7, 2019, http://www.besticity.com/info/245350.
[135] Li You, "Tech-Savvy Hangzhou Tries Out New 'City Brain,'" *China Daily*, December 10, 2018, http://www.chinadaily.com.cn/cndy/2018-12/10/content_37378664.htm.
[136] Jenny W. Hsu, "Alibaba Cloud Launched 'ET City Brain 2.0' in Hangzhou," Alizila.com, September 20, 2018, https://www.alizila.com/alibaba-cloud-launched-city-brain-2-0-hangzhou/.
[137] Michelle Toh and Leonie Erasmus, "Alibaba's 'City Brain' Is Slashing Congestion in Its Hometown," CNN Business, modified January 15, 2019, https://www.cnn.com/2019/01/15/tech/alibaba-city-brain-hangzhou/index.html.
[138] See "Shanghai "Citizen Cloud App" Goes Online to Open Up the "Last Kilometer" of Urban Public Service," Xinhua, December 1, 2016, http://www.chinanewsportal.com/news/2016/1201/1709/5d418d2d6a1c4767d6963310 and Chia Jie Lin, "Five Chinese Smart Cities Leading the Way," GovInsider, July 10, 2018, https://govinsider.asia/security/five-chinese-smart-cities-leading-way/.
[139] Yang Yongyan 杨永燕, "[Guangzhou Regional Information Platform Opens Up Access to Entire Citiy's Health Supervision Duties] (广州区域信息平台打通全市医疗任督二脉)," China Digital Health Network (中国数字医疗网), March 24, 2014, http://www.hc3i.cn/php/marticle.php?id=29077.
[140] Chia Jie Lin, "Five Chinese Smart Cities Leading the Way," GovInsider, July 10, 2018, https://govinsider.asia/security/five-chinese-smart-cities-leading-way/.
[141] Zhou Mo, "Shenzhen Becoming 'Smarter,'" *China Daily*, modified June 27, 2018, http://www.chinadaily.com.cn/a/201806/27/WS5b32ef3da3103349141df2ba.html.

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III | "The Masses Have Sharp Eyes:" Technology and Mass Surveillance in Chinese Smart Cities

Key Findings

- Chinese government officials are embracing smart city technologies—especially IoT, mobile internet, cloud computing, and big data—to expand, improve, and automate information collection and analysis for mass surveillance.
- Much of the implementation of this "smart surveillance" occurs at the local level, although local surveillance programs are increasingly tapping into national-level information and network resources, augmenting local programs as part of development towards a fully-integrated national surveillance system.
- Massive local implementation of smart city surveillance has created difficulties in upgrading surveillance equipment and fostered a low degree of standardization and integration for systems deployed in different regions and localities in China.
- Even as China embraces smart cities technologies to surveil its people, it will continue to use volunteers to monitor the actions of the general population and to augment smart city surveillance. This practice of "mass defense, mass rule" (群防群治) is a continuation of historical CCP surveillance efforts that stands to benefit greatly from increased use of smart cities technologies.
- China's current mass surveillance efforts and the industry that supports them are some of the largest and most prolific in the world, but China's future ambitions for domestic mass surveillance likely dwarf the size and scope of its current extensive surveillance state. The CCP's intent to deploy 626 million video cameras by 2020, widening adoption of artificial intelligence, and functionally nonexistent civil rights protections are laying the groundwork for a digital panopticon.

One facet of smart city development that has attracted considerable worldwide attention is the danger that the vast quantities of data collected by smart city technologies could be used by authorities to surveil the populace. In the United States, groups ranging from the American Planning Association to the American Civil Liberties Union have voiced legal and ethical concerns about the privacy implications of smart city technologies.[148] In China, where civil liberties protections are functionally nonexistent, public security officials have openly embraced the use of smart city technologies to surveil the citizenry in response to a call from the central government to "integrate the informatization of public security into the overall planning and construction of smart cities" (将社会治安防控信息化纳入智慧城市建设总体规划).[149]

[148] See Brian Barth, "Smart Cities or Surveillance Cities?" *Planning Magazine*, March 2019, https://www.planning.org/planning/2019/mar/smartcities/ and Chad Marlow and Maryiam Saifuddin, "How to Stop 'Smart Cities' Becoming 'Surveillance Cities'," ACLU, September 17, 2018, https://www.aclu.org/blog/privacy-technology/surveillance-technologies/how-stop-smart-cities-becoming-surveillance-cities.

[149] General Office of the Central Committee of the Chinese Communist Party and General Office of the State Council of the People's Republic of China, "[Opinion on Strengthening Construction of the Societal Safety and Control System] (关于加强社会治安防控体系建设的意见)," April 13, 2015, http://politics.people.com.cn/n/2015/0414/c1001-26839083.html.

Although the Chinese government rarely uses overt terminology such as "mass surveillance" to describe the role of smart city technologies in their public security ecosystem, this is unmistakably their intended function.[150] In regions such as Xinjiang and Tibet where China is aggressively monitoring its minority populations, smart city technologies are a crucial component of campaigns of surveillance and repression. As a result, China's development and acquisition of constituent technologies such as the Internet of Things, big data, cloud computing, and satellite geolocation, poses privacy and human rights concerns far beyond what one encounters elsewhere.

China's approach to mass surveillance poses unique analytical challenges. In particular, China prefers, whenever possible, for its citizens to practice self-surveillance and self-policing, since a cowed citizenry accomplishes the state's objectives without massive expenditure of state resources. This, however, necessitates perpetuating the belief that mass surveillance is comprehensive, omniscient, and highly efficient. The regime and its partners therefore have a strong incentive to convince the public and the world that China's mass surveillance system is highly advanced and perfectly effective, even if neither are necessarily true.

This chapter uses a variety of authoritative sources to assess the extent to which smart city technologies enable mass surveillance to be more effective, including writings from Chinese public security officials and researchers that describe the prospects and challenges of implementation for various forms of mass surveillance. Although the real-world implementation of any given surveillance technology often varies considerably between different Chinese municipalities, these baseline assessments offer a general sense of the capability and development trajectory of China's mass surveillance environment.

The first section of this chapter contextualizes China's current mass surveillance efforts by briefly outlining the CCP's longstanding history of surveilling its civilian population and stated justifications for doing so. The second section describes recent efforts to use technology to improve mass surveillance, detailing the impact of smart city technologies on Chinese capabilities. Finally, the chapter concludes with a brief comparative assessment of China's mass surveillance efforts relative to those of other nations.

The Evolution of Mass Surveillance in the People's Republic of China

China's mass surveillance efforts have attracted considerable international attention in recent years. Much of this attention has focused on the government's intensified surveillance of the Uyghur ethnic minority in the Xinjiang region, but foreign media has also devoted substantial press to the deployment of advanced surveillance technologies in major Chinese cities and on the Chinese internet.

China's program of mass surveillance is actually an outgrowth of long-running CCP surveillance efforts aimed at controlling both their cadres and the general populace. Following the establishment of the PRC in 1949, the Party sought to solidify its hold over society using both a formal state coercive apparatus comprised of public security organs (公安机关) and an informal public participation in surveillance in accordance with a concept known as "mass defense, mass

[150] "Mass surveillance" can be rendered as "大规模监视," but authoritative Chinese documents do not use this phrase. Instead, Chinese books, documents, and journal articles frequently use more specific terms to describe different components of surveillance: for instance, video surveillance is rendered as "视频监控," and internet surveillance and censorship is often rendered as "网络舆情工作."

rule" (群防群治).[151] While the former relied upon regular public security patrols and law enforcement, "mass defense, mass rule" relied upon public security committees (治安保卫委员会) formed by local leaders to maintain domestic social stability and suppress potentially counter-revolutionary activity. This dual approach to mass surveillance ensured that public security organs could rely upon not only their own investigative apparatus but also grassroots surveillance for information on those who might run afoul of the Party's mass line.[152]

The PRC's "reform and opening up" (改革开放), from 1978 onward, presented new challenges for China's internal security apparatus that it sought to mitigate using technology. The rapid expansion of the Chinese economy throughout the 1980s and 1990s was accompanied by significant internal population migration, which undercut the ability of local cadres and grassroots security organizations to effectively surveil local populations. While Party officials may not necessarily have foreseen this type of challenge when reforms began, the Party's public security apparatus was well-positioned to respond by accelerating its development and deployment of surveillance technologies. In 1978, the Ministry of Public Security (MPS) established the 1st, 2nd, and 3rd Research Institutes, each of which has developed a range of surveillance technologies ranging from video cameras to computer network and internet surveillance tools. The Ministry also established a national-level Science and Technology Bureau (科学技术局), with corresponding departments and offices created within the provincial and municipal Public Security Bureaus (PSBs).[153] The successors to these entities are responsible for planning and implementing technical mass surveillance methods for China's public security apparatus today.

The turn towards technology has translated into several notable efforts to improve mass surveillance using information and communications technologies, even well before China's official embrace of smart cities. Many of these efforts have been iterative and built upon progress made during prior initiatives. For instance, the 1998 program known as Golden Shield (金盾工程), which involved the construction of a nationwide information network for the MPS and its provincial and municipal counterparts,[154] was followed by the 3111 Project in 2005, which installed video monitoring systems in 22 cities on an experimental basis.[155] The Skynet Project (天网工程) began supporting the installation of video surveillance systems across the country shortly thereafter, followed most recently by the Sharp Eyes (雪亮工程) program in 2015.[156] The timing of these city informatization initiatives and major surveillance improvement programs is illustrated in the diagram below:

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[151] Zhao Wei 赵薇, "[A Narration on Mass Defense and Mass Rule Work in the Beijing Streets During the 1950s] (20 世纪 50 年代北京街道群防群治工作述论)," *Beijing Party History 北京党史* no. 1, (2016): 5-12.

[152] Zhao Wei 赵薇, "[A Narration on Mass Defense and Mass Rule Work in the Beijing Streets During the 1950s] (20 世纪 50 年代北京街道群防群治工作述论)," *Beijing Party History 北京党史* no. 1, (2016): 5-12.

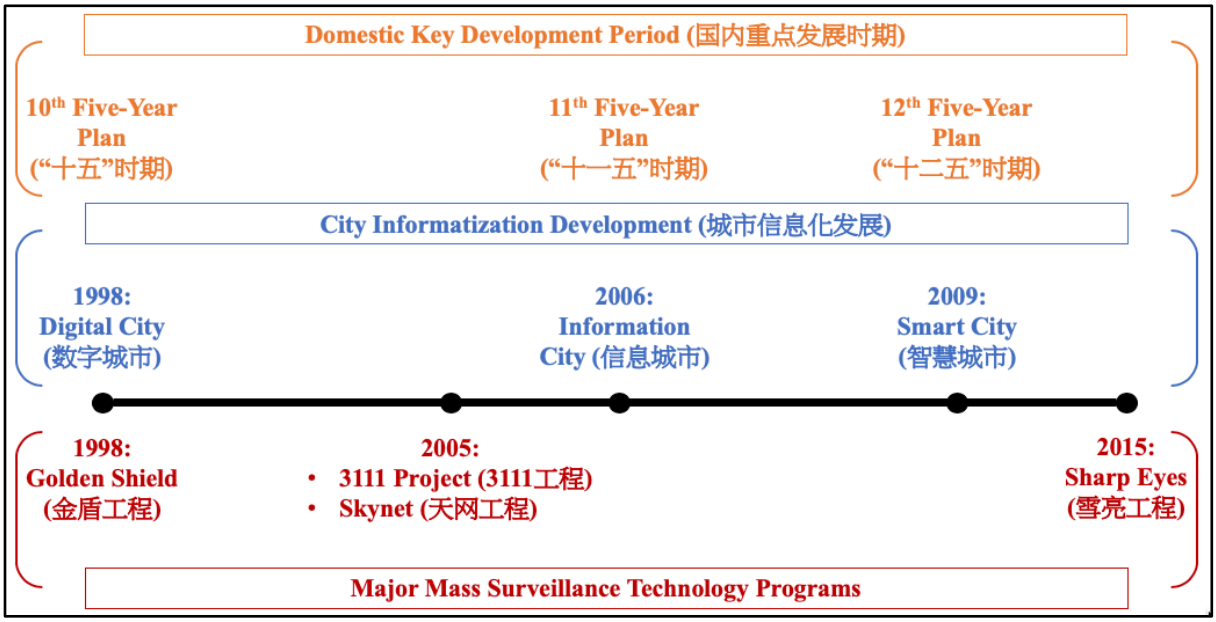
[153] People's Public Security History Draft Editing Small Group, *A Historical Manuscript of People's Public Security (中国人民公安史稿)* (Beijing: Police Officer Education Press, 1997): 410-412.

[154] "[Golden Shield Project] 金盾工程," *China Net 中国网,* February 27, 2003, http://www.china.com.cn/zhuanti2005/txt/2003-02/27/content_5283732.htm.

[155] "[Interpreting The Nine-Department Document on Public Security Monitoring Network] (解读九部委公共安全视频监控文件)," *China Security Industry Network 中国安防行业网,* http://www.21csp.com.cn/zhanti/9BWJD/index.html.

[156] Min Yue 闵玥, ed., "[Sharp Eyes Project Guards Peaceful China] ("雪亮工程"守望平安中国)," *China Peace Network 中国长安网*, October 16, 2017, http://www.chinapeace.gov.cn/2017-10/16/content_11433841.htm.

Figure 4: Chinese City Informatization and Mass Surveillance Technology Programs



Source: General Office of the Central Committee of the Chinese Communist Party and General Office of the State Council of the People's Republic of China.[157]

Recent authoritative Party and state documents calling for improved mass surveillance frequently justify these efforts in terms of public security (公共安全) or societal security (社会安全). The April 2015 "Opinion on Strengthening Construction of the Societal Safety and Control System" (关于加强社会治安防控体系建设的意见, henceforth referred to as the 2015 Opinion), gives the consensus view within the Party regarding the importance of mass surveillance in ensuring public security. The document, issued by the General Office of the CCP Central Committee and the State Council General Office, called for authorities to expand the scope of the "social safety control network" (治安防控网) as part of a broader effort to increase the visibility of public security issues, improve infrastructure security, and identify and mitigate events such as disruptive crimes and unrest. While the Opinion does not explicitly include a Chinese term for "mass surveillance," it calls for the accelerated deployment of video monitoring systems and internet surveillance in urban and rural areas to be integrated with other smart city technologies as part of an overall public security effort.[158]

This emphasis on societal security has taken on greater significance as part of Xi Jinping's recently expanded articulation of Chinese national security interests. In 2014, Xi included societal security in a description of his overall national security concept during the first meeting of the Central Committee's National Security Commission (中央国家安全委员会), signaling that in his view

[157] Information derived from Jin Jiangjun 金江军, ed., *Leading Cadre Reader for Network Security and Informatization (网络安全和信息化党政领导干部读本)* (Beijing: Central Committee Party School Press: 2017), 21.
[158] General Office of the Central Committee of the Chinese Communist Party and General Office of the State Council of the People's Republic of China, "[Opinion on Strengthening Construction of the Societal Safety and Control System] (关于加强社会治安防控体系建设的意见)," April 13, 2015, http://politics.people.com.cn/n/2015/0414/c1001-26839083.html.

the concept was a prominent component of broader national and regime security.[159] The importance of public and societal security to the Party's continued rule of China virtually ensures that Party officials will continue to emphasize mass surveillance efforts, including through smart city technologies.

Smart City Improvements for Mass Surveillance

Indeed, Party cadres at the highest levels of the Chinese leadership have frequently stressed the importance of smart city technologies in maintaining public security. In May 2013, Meng Jianzhu (孟建柱), then-Secretary of the Central Committee's Political and Legal Affairs Commission (中共中央政法委员会), emphasized that "public security construction (平安建设) should be integrated into the planning and requirements of smart cities…in order to promote the "intelligentization" (智能化) of public security construction efforts."[160] The aforementioned 2015 Opinion was more specific, calling for "regular use of next-generation internet, Internet of Things, cloud computing, smart sensors, remote sensing, satellite positioning, geographic information systems, and other technologies" in public security systems. The Opinion also explicitly called for the accelerated expansion of China's public security video monitoring systems as part of an Internet of Things Security Area Testbed (物联网安防小区试点), especially in rural areas, large cities, and public spaces.[161]

It is clear from relevant books and other Party documents that the CCP intends to use multiple smart city technologies to substantially augment and even revolutionize its mass surveillance capabilities. Many of the technology areas named by the 2015 Opinion are identified as smart city technologies in relevant Party instructional materials which explicitly describe mass surveillance as one of their possible applications. One 2016 volume written for Party leadership cadres contains a summary of the role that "next-generation information technologies" (新一代信息技术) play in smart city development, identifying "automatic monitoring and control" (自动监测, 监控) as a primary use of Internet of Things technologies and arguing that mobile internet development should be carried out to serve the needs of mobile law enforcement (移动执法).[162]

Other Party works see the potential for new predictive capabilities in big data. For example, a 2017 volume published by the Central Party School argues that big data can improve the regulation and monitoring of internet opinion by mining the "opinions, behaviors, emotions, footprints, and other characteristics" of netizens in order to "unearth hidden negative opinions, predict their

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[159] Central Committee Party School International Strategy Research Institute, ed., *Research on National Security Strategy with Chinese Characteristics (中国特色国家安全战略研究)* (Beijing: Central Committee Party School Press, 2016), 144.

[160] Meng Jianzhu 孟建柱, "[Construct a Peaceful China From a High Starting Point] (在更高起点上全面推进平安中国建设)," *Qiushi 求是*, no. 14 (2015). Intelligentization (智能化) is regarded as a critical feature of informatization (信息化), referring to the use of computers for automatic recognition and data and information processing in order to transform data into information. See Jin Jiangjun 金江军, ed., *Leading Cadre Reader for Network Security and Informatization (网络安全和信息化党政领导干部读本)* (Beijing: Central Committee Party School Press, 2017), 1.

[161] General Office of the Central Committee of the Chinese Communist Party and General Office of the State Council of the People's Republic of China, "[Opinion on Strengthening Construction of the Societal Safety and Control System] (关于加强社会治安防控体系建设的意见)," April 13, 2015, http://politics.people.com.cn/n/2015/0414/c1001-26839083.html.

[162] Jin Jiangjun 金江军, ed., *Leading Cadre Reader for Network Security and Informatization (网络安全和信息化党政领导干部读本)* (Beijing: Central Committee Party School Press, 2017), 21.

development, intervene in advance, and effectively resolve public opinion problems to reduce the risk of societal safety incidents."[163]

Table 7: Roles of Next-Generation Information Technologies in Smart Cities[164]

	Definition	Role	Use Areas
Internet of Things (物联网)	Communication network between devices	Collecting data	Automatic monitoring (surveillance) and control[165]
Cloud Computing (云计算)	Expandable/shrinkable "lake" to provide unified computing resources	Processing data, providing application services	Data centers, software and information service platforms
Mobile Internet (移动互联网)	Wireless communication network	Transporting data, providing mobile application services	Mobile applications (mobile office work, mobile law enforcement)
Big Data (大数据)	Ultra-large amounts of data with different structures, able to be used to illuminate data with valuable information	Data mining, data visualization	Industry and government intelligentization

Even when Party literature does not give specific guidance as to how smart city technologies will be used to improve mass surveillance, academic papers published by technical public security personnel articulate a range of possible uses for these technologies. There is a particularly wide body of published academic research conducted by state personnel focusing on the surveillance of internet opinion and various aspects of video surveillance. Examples of detailed research abound: one 2016 issue of the MPS 3rd Research Institute's technical journal featured details of a notional internet monitoring system that would use a cloud computing platform to carry out trend analysis of Tibetan internet opinion.[166] An August 2017 article in the technical journal of the MPS 1st Research Institute described the use of facial recognition technologies on video surveillance data collected during a six-week evaluation period from July to August 2016 in Qinhuangdao.[167] Taken together, these articles strongly suggest that a number of local governments have incorporated a wide range of smart city technologies into their mass surveillance efforts in order to improve information collection and analysis capabilities.

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[163] Central Committee Party School International Strategy Research Institute, ed., *Research on National Security Strategy with Chinese Characteristics (中国特色国家安全战略研究)* (Beijing: Central Committee Party School Press, 2016), 154.

[164] Jin Jiangjun 金江军, ed., *Leading Cadre Reader for Network Security and Informatization (网络安全和信息化党政领导干部读本)* (Beijing: Central Committee Party School Press, 2017), 21.

[165] This cell uses the term "自动监测，监控," rendered in English as "automatic monitoring and control." The term "监控" is frequently used to refer to surveillance systems of all kinds.

[166] Jiang Tao 江涛, Jiang Jing 江静, Dai Yugang 戴玉刚, and Li Ailin 李艾林, "Research on Tibetan Public Opinion Platform of Cloud Analysis System (藏文舆情云分析系统平台研究)," *Netinfo Security 信息网络安全,* no. 9, (2014): 92-94.

[167] Cheng Dajiang 程大江 and Huang Lin 黄林, "[Construction and Application of Facial Recognition Technology in Qinhuangdao Police Duties] (人脸识别技术早秦皇岛警务实战中的建设与应用)," *Police Technology 警察技术,* no. 4, (2017): 79-82.

Local Implementation, National Aspirations

Many Chinese government plans for "smart surveillance" systems are coming to fruition, and although they are often deployed in a piecemeal fashion in different locales, they are increasingly equipped with access to national-level information resources. For instance, many of the smart city command centers installed in local public security departments have differing specifications and capabilities but are increasingly built to function interoperably and tap into shared national-level resources, namely the national-level Public Security Intranet (公安内网) and the national E-Government network. For example, Wujiang District Public Security Department personnel noted in a joint August 2018 article with specialists from the MPS 1st Research Institute and Dingqiao Communications Technology Company (鼎桥通信技术有限公司) that their cloud-enabled command center had access to the aforementioned national Public Security Intranet, a local video dedicated network (视频转网) and group dedicated network (集群专网), and an unspecified public network (公网).[168] Further south, a June 2019 article by members of the Shenzhen Public Security Department proposed a command platform with connectivity to the "Four Networks (四网)," namely the national E-Government Network (政务网), industrial networks (企业网), the internet (互联网) , and a Police Duty Network (警务网) that would include connectivity to the national Public Security Intranet, a mobile dedicated network, and a video dedicated network.[169] The similarities (and slight variations) in network connectivity between public security command centers in different provinces are indicative of broader ongoing attempts to ensure compatibility across regions and throughout the nation.

At the same time that smart city technologies are increasingly used to improve mass surveillance, public security authorities have continued standardizing certain aspects of their technology. The MPS has issued a range of guiding documents and technical standards intended to govern implementation of smart city information technology. For instance, the 2016 National Public Security Mobile Police Service Construction Technical Solution (全国公安移动警务建设总体技术方案) contains requirements and guidelines for using mobile internet to increase police effectiveness. Technical standard GB/T 28181-2011, also issued by the MPS, gives specifications for information transport, switching, and control for video monitoring systems. These are a few examples of efforts to encourage standardization across different use cases for smart city surveillance technologies throughout China.

Given China's abundant research and development of smart city surveillance technologies, increasing standardization, and widespread deployment in a variety of Chinese localities, it is clear that Party authorities aspire to build a more unified tapestry of smart city mass surveillance systems that can share resources at the national level. Nevertheless, several public security officials have acknowledged that the breakneck pace of development and deployment of various smart city surveillance technologies has resulted in systemic impediments to further development. Some of these problems are described in the next section.

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[168] Wang Hanjie 王汉杰, Lao Guofang 劳国芳, Zuo Kefeng 左克锋, Liao Chengbin 廖承斌, and Wu La 乌拉, "[The Sharp Weapon of Smart Public Security: Cloud Command Platform] (智慧公安的利器 – 云指挥平台)," *Police Technology 警察技术,* no. 4, (2018): 70-76.

[169] Zhang Yong 张勇 and Yu Lian 余廉, "[Next Generation Mobile Police Duty Helps Shenzhen's 'AI + New Police Duty' Primary Analysis (新一代移动警务助力深圳 "AI+新警务"之浅析)," *Police Technology 警察技术*, no. 2 (2019): 7-10.

The Mass Problems of Smart Surveillance

Chinese public security personnel stationed around the country have faithfully carried out Party directives to incorporate smart city technologies into existing mass surveillance programs, but the uneven introduction and development of smart city technologies in local surveillance systems has resulted in a number of systemic problems. Public security officials acknowledge that these issues are often caused by the sheer scale of smart surveillance programs, and that these problems continue to hinder Chinese smart surveillance efforts, even with the benefit of massive amounts of funding and general awareness of the problems at hand.

One commonly cited roadblock in the deployment of effective smart city surveillance technologies is the low degree of standardization and integration. Many of the technical standards that lay out specifications for surveillance equipment are optional or intended for reference only, resulting in a surveillance industry awash in technical standards but deficient in real-world interoperability. Different localities implement their own surveillance solutions with their own preferred vendors. While in theory these deployments are compliant with broad guidelines set forth by these documents, in practice many systems are comprised of "isolated information islands" (信息孤岛) in which vast amounts of public security data reside in non-standardized or incompatible storage platforms outside the reach of the public security officials that could use it.[170]

While officials attempt to standardize equipment and connect it to national information resources as described in the previous section, the maturity and effectiveness of any given smart city surveillance technology remains up for debate. For example, according to technical researchers writing in the June 2019 issue of *Police Technology*, the Chinese government's facial recognition technology continues to suffer from a bevy of technical difficulties, including impractically stringent passive face-matching requirements and impossibly high data bandwidth requirements for integration with other systems.[171] These technical impediments continue to constrain China's mass deployment of the most advanced surveillance technology.

Another frequently articulated bottleneck in smart surveillance deployment is the difficulty in upgrading equipment, especially surveillance cameras. The 2015 "Opinion on Problems in Strengthening Public Security Video Surveillance Construction Network Application Work" (关于加强公共安全视频监控建设联网应用工作的若干意见), which was issued jointly by nine different administrative departments, made officials responsible for upgrading all cameras to high-definition models by 2020. The Opinion also called for "100 percent coverage of important public areas" and "100 percent coverage of important industrial locations" with 100 percent networked capability, and an overall operational readiness level of 95 percent for industrial areas and 98 percent for public areas in all-weather, day-or-night conditions.[172] However, repairing or upgrading massive numbers of surveillance cameras installed by past initiatives, however, presents

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[170] Li Xiafeng 李夏风, Wang Zhonglin 王忠林, and Wang Hong 汪宏, "[Construction and Application of Public Security Big Data Facial Recognition Platform] (公安人脸大数据平台的建设与应用)," *Police Technology 警察技术,* no. 2, (2019): 64-70.

[171] Li Xiafeng 李夏风, Wang Zhonglin 王忠林, and Wang Hong 汪宏, "[Construction and Application of Public Security Big Data Facial Recognition Platform] (公安人脸大数据平台的建设与应用)," *Police Technology 警察技术,* no. 2, (2019): 64-70.

[172] National Development and Reform Commission et al., "[Opinion on Problems in Strengthening Public Security Video Surveillance Construction Network Application Work] (关于加强公共安全视频监控建设联网应用工作的若干意见)," May 6, 2015, http://www.ndrc.gov.cn/zcfb/zcfbtz/201505/t20150513_691578.html.

an enormous challenge even for officials with the mandate, willpower, and funding to carry out these tasks. Additionally, researchers have noted that some of China's most confounding technical difficulties (namely the stringent technical collection requirements for facial recognition) cannot be resolved by simply installing more cameras to cover greater areas.[173] Nevertheless, China's highest authorities continue to emphasize coverage percentage and the elimination of any "blind spots" (盲区) rather than measures that would more directly mitigate the issue.[174] Worse, the sheer difficulty of upgrading hundreds of millions of surveillance cameras is amplified by the lack of standardization across localities.

A more infrequently acknowledged problem is a continued reliance upon humans to carry out mass surveillance despite introduction of technological solutions to increase automation. Official sources do not describe manpower-intensive mass surveillance, although one August 2019 article by a specialist in the MPS Science and Technology Informatization Bureau (科技信息化局) noted that public security command centers often continued to use obsolete technology, making it difficult to integrate artificial intelligence, mobile internet, cloud computing, and big data into public security intelligence work.[175] Unofficial sources suggest that among other aspects of mass surveillance, manual data entry continues to drive much of China's fledgling smart surveillance panopticon: a May 2019 report by Human Rights Watch revealed that a MPS Integrated Joint Operations Platform mobile application relied heavily on public security officers to manually enter pertinent data on surveillance targets in Xinjiang.[176]

These systemic issues continue to bedevil the latest smart city surveillance efforts. As of September 2017, public security officials from Chuzhou noted that the Sharp Eyes Project suffered from all of the issues described above.[177] Other sources, like those described above, suggest that officials continue to wrestle with technical problems in mass surveillance and the impact of the localized, mass deployment approach for smart surveillance that the central government has adopted.

The Past as Future

Even if researchers successfully identify and iron out the kinks in smart city mass surveillance programs, the CCP is unlikely to completely replace the "mass defense, mass rule" component of public surveillance with smart city technology. While smart surveillance could substantially reduce the human workload of surveilling 1.4 billion people, the Party's use of smart city technologies is meant to enhance its mass approach to surveillance rather than replace the "mass defense, mass rule" concept entirely. For instance, the surveillance work carried out by the formal

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[173] Li Xiafeng 李夏风, Wang Zhonglin 王忠林, and Wang Hong 汪宏, "[Construction and Application of Public Security Big Data Facial Recognition Platform] (公安人脸大数据平台的建设与应用)," *Police Technology 警察技术,* no. 2, (2019): 64-70.

[174] National Development and Reform Commission et al., "[Opinion on Problems in Strengthening Public Security Video Surveillance Construction Network Application Work] (关于加强公共安全视频监控建设联网应用工作的若干意见)," May 6, 2015, http://www.ndrc.gov.cn/zcfb/zcfbtz/201505/t20150513_691578.html.

[175] Li Li 李力, "[Discussion on New Generation Public Security Command Center Command Ecosystem] (新一代公安指挥中心指挥体系及技术探讨)," *Police Technology 警察技术*, no. 4, (2019): 4-7.

[176] Maya Wang, "China's Algorithms of Repression: Reverse Engineering a Xinjiang Police Mass Surveillance App," Human Rights Watch, May 2019, https://www.hrw.org/sites/default/files/report_pdf/china0519_web.pdf.

[177] Liang Yidao 梁义道 and Peng Xiaolei 彭小磊, "[Using the Rise of the Internet of Things to View the Upgrade of the Skynet Project] (从物联网兴起看"天网工程"升级改造)," *Chuzhou Net 滁州网,* September 22, 2017, http://www.chuzhou.cn/2017/0922/332002.shtml.

public security apparatus is still frequently augmented by the surveillance efforts of private companies. In this version of "mass defense, mass rule" for a new era of information technology, private companies like Tencent and Alibaba are part of the collective "masses," actively cooperating with state-owned enterprises and government authorities to surveil and censor mobile internet traffic as well as develop better surveillance methods.[178]

The Party's continued dedication to "mass defense, mass rule" is exemplified in a literal human sense in its latest video surveillance expansion program, the Sharp Eyes Project (雪亮工程). Sharp Eyes derives its name from Mao Zedong, who once said that "in times of need, the masses have sharp eyes; when not required, the masses do not recognize the truth (需要的时候，群众的眼睛是雪亮的；不需要的时候，群众是不明真相的)."[179] As befits its name, Sharp Eyes hands over responsibility for monitoring neighbors, residents, and passersby to vetted local volunteers, who watch surveillance video feeds that are piped to their living rooms through their network-connected smart TVs.[180] Video screenshots suggest that aside from the companies that research, manufacture, and install video cameras, Sharp Eyes also relies on cooperation from local state-run cable television companies.[181]

Ultimately, China's prospects for successfully implementing a technological panopticon in concert with its existing mass approach to surveillance depend largely upon whether or not public security authorities can eliminate the systemic and technical roadblocks described in the sections above. For the foreseeable future, however, the CCP will continue to rely upon "mass defense and mass rule" augmented by smart city technologies to secure its grip on power. While this philosophy may suggest that smart city technologies are not yet mature enough to be fully deployed in enhancing mass surveillance, it is also perhaps due to the CCP's historical approach in this sphere and is likely to remain a centerpiece of the CCP's technological surveillance state well into the future.

Chinese Mass Surveillance in an International Context

The use of smart city technologies in Chinese mass surveillance naturally prompts the question of whether China's approach is substantively different than the approaches other countries have undertaken. By almost any rough measure, China's mass surveillance programs are quantitatively and qualitatively more prolific than those of almost every other nation in the world.

Rough quantitative measures suggest that China's mass surveillance program is one of the biggest on Earth and is expanding at a rapid clip. In 2017, China reportedly had 176 million surveillance cameras, and by July 2018, a separate report estimated that number had risen to 200 million

[178] Among other examples, see He Jie 何杰, Zhu Meiling 朱美玲, Xu Yue 胥月, Liu Wangyang 刘汪洋, Li Xuyang 李旭阳, and Zeng Runxi 曾润喜, "[Risk Assessment and Governance of Internet Social Security: A Regional Comparative Study Based on Index System Security Data] (网络社会安全风险评估与治理研究-一项基于指标体系和安全数据的区域比较研究)," *Journal of Intelligence 情报杂志* 38, no. 1, (2019): 119-126.

[179] "[Ten Classic Quotes from Mao Zedong Sayings] (《毛主席语录》经典十句)," *Chairman Mao Memorial Network 毛主席纪念网*, March 29, 2019, http://www.crt.com.cn/news2007/news/MZXYULU/2019/3/19329151922479KJ8385D5K73A03IF.html.

[180] Min Yue 闵玥, ed., "[Sharp Eyes Project Guards Peaceful China] (雪亮工程"守望平安中国)," *China Peace Network 中国长安网*, October 16, 2017, http://www.chinapeace.gov.cn/2017-10/16/content_11433841.htm.

[181] Min Yue 闵玥, ed., "Sharp Eyes Project Guards Peaceful China] (雪亮工程"守望平安中国)," *China Peace Network 中国长安网*, October 16, 2017, http://www.chinapeace.gov.cn/2017-10/16/content_11433841.htm.

surveillance cameras, some four times as many cameras in aggregate as in the United States.[182] These figures amount to a ratio of about 1 camera for every 7.1 people in China, compared to about 1 camera for every 6.58 people in the United States. Although these ratios suggest that China has fewer cameras per capita than the United States, China is planning to greatly expand its coverage: some sources claim that China plans to increase that figure to some 626 million cameras by the end of the decade, which would mean a ratio of approximately 1 camera for every 2.27 people in China.[183]

While China does not itemize its public security expenditures to account for spending on mass surveillance equipment, its public security budget has ballooned in recent years, with a substantial portion of the increase undoubtedly directed towards surveillance technology. According to official figures, China's central government public security expenditures totaled some RMB 18.6 billion ($2.6 billion) in 2016, rising to RMB 21.5 billion ($3.0 billion) in 2017 and then to RMB 46.7 billion ($6.5 billion) in 2018 for an increase of nearly 2.5 times in a span of two years.[184] While these figures are comparatively paltry—the central government of the United Kingdom spends £8.6 billion ($10.8 billion) on its police[185]—the dramatic increase in China's central public security budget highlighted a committed investment in internal security dating back to at least 2011, when China's internal security budget eclipsed its defense spending.[186]

The industry that supports China's smart surveillance is similarly gargantuan. China's surveillance technology companies are behemoths: they sell their wares with few privacy or legal constraints at home and are rapidly expanding their presence abroad, behavior which will be described in greater detail in the following chapter. For instance, Hikvision, a subsidiary of state-owned defense electronics conglomerate China Electronics Technology Group Co., Ltd. (CETC),[187] was the single largest surveillance equipment maker on the planet in 2017, boasting some 21.4 percent of the world's market share for closed-circuit television cameras and other surveillance equipment.[188]

What makes China's mass surveillance program unique is not simply its aggregate relative reach, or substantial increases in government funding, or the increasing demand for surveillance equipment described above. Substantive qualitative differences between China's smart city mass

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[182] Xiao Qiang, "The Road to Unfreedom: President Xi's Surveillance State," *Journal of Democracy* 30*,* no.1 (January 2019): 53-67; Paul Mozur, "Inside China's Dystopian Dreams: AI, Shame, and Lots of Cameras," *New York Times,* July 8, 2018, https://www.nytimes.com/2018/07/08/business/china-surveillance-technology.html.
[183] Xiao Qiang, "The Road to Unfreedom: President Xi's Surveillance State," *Journal of Democracy* 30*,* no.1 (January 2019): 53-67.
[184] Figures obtained from budget documents available at Ministry of Finance of the People's Republic of China, "[Financial Data] (财政数据)," Ministry of Finance Government Affairs Information, http://yss.mof.gov.cn/zhengwuxinxi/caizhengshuju/.
[185] National Audit Office, "Financial Sustainability of Police Forces in England and Wales 2018," September 11, 2018, https://www.nao.org.uk/wp-content/uploads/2018/09/Financial-sustainability-of-police-forces-in-England-and-Wales-2018.pdf#page=6.
[186] Chris Buckley, "China Internal Security Spending Jumps Past Army Budget," Reuters, March 5, 2011, https://www.reuters.com/article/us-china-unrest/china-internal-security-spending-jumps-past-army-budget-idUSTRE7222RA20110305.
[187] Hangzhou Hikvision Digital Technology Co., Ltd., "Hikvision 2018 Annual Report," April 20, 2019, http://file.finance.sina.com.cn/211.154.219.97:9494/MRGG/CNSESZ_STOCK/2019/2019-4/2019-04-25/5252841.PDF.
[188] Hikvision Digital Technology Company, "Hikvision Continues its Leading Position in IHS Markit 2017 Report," *PRNewswire,* June 21, 2017, https://www.prnewswire.co.uk/news-releases/hikvision-continues-its-leading-position-in-ihs-markit-2017-report-629838733.html.

surveillance capabilities and those of other nations lie just below the surface. China is using old methods and new technologies to advance the development of its smart surveillance state, including both China's ongoing use of "the masses" as a central component of mass surveillance and reliance on new smart city technologies to augment the perception (if not necessarily the reality) of omnipresent surveillance. Governed by a Communist Party that is ever more concerned about domestic threats to its continued rule and watched by both neighbors and police equipped with ever-present surveillance cameras and algorithms, China's population is likely to continue living under the sharp eyes of the masses and the watchful algorithms of the Party for the foreseeable future. As the Chinese regime deepens its embrace of smart mass surveillance, Chinese companies have raced to develop more effective smart city technologies, and increasingly, market them abroad.

IV | China's Export of Smart Cities

Key Findings

- Chinese companies have been successful at promoting and installing smart cities technologies around the world. Analysts identified 398 reported cases of 34 different Chinese firms exporting smart cities technologies through involvement in smart cities development projects in a total of 106 countries.
- The Belt and Road Initiative, China's signature foreign policy, highlights smart cities as a "strategic opportunity" for Chinese firms to expand abroad. While these plans do not include specifics about future expansion, it is possible to infer that smart city promotion as part of the Belt and Road Initiative will continue to be an international priority with backing from the highest levels of the Chinese government.
- In developing nations, smart cities projects focused on installing surveillance technologies and network infrastructure have been notable successes of Chinese national champions like Huawei, often with the financial backing of state-owned banks like the Export-Import Bank of China.
- Chinese firms see more developed countries as valuable sources of technology and expertise as well as markets for Chinese technology, frequently developing partnerships and establishing joint laboratories in these countries. These partnerships are used in part to promote Chinese technology standards and expand access to advanced technology and in part to improve international perceptions of Chinese firms.
- Though clear information on data sharing arrangements between Chinese technology firms and local governments abroad could not be found, expanding access to global data sets to include these firms gives them a market advantage and may aid Chinese intelligence collection efforts.
- Through all of these avenues, the growth of Chinese smart cities exports presents a serious economic and security challenge to the United States.

The Chinese government is directing significant funds toward surveillance, e-government, big data, 5G, and other smart cities technologies domestically, and the export of these systems is a natural outgrowth of this investment.[189] China has become one of the most important exporters of smart city technology by supplying foreign governments with communications and surveillance infrastructure. According to the National Bureau of Economic Research, this surge of exports in data and communications infrastructure is closely linked to China's status as the world's largest official creditor, which positions it advantageously to supply both the labor and technologies for many of the projects it finances.[190] This chapter provides a data-driven investigation quantifying the overall contribution of Chinese companies to building smart cities across the globe. It first introduces Chinese policy context for the export of smart cities technologies through the Belt and Road Initiative (BRI), state financing, and international standards-setting; then discusses the methodology analysts used to identify 398 reported cases of Chinese firms involved in smart city development projects in a total of 106 countries; presents 5 case studies that illustrate general

[189] Gao Jianjin 高建进 and Zhang Shiyao 张诗瑶, "[Striding up the Road of an Information-Strong Country] (在信息强国的道路上阔步前行)," *Guangming Daily 光明日报*, May 5, 2019, https://news.gmw.cn/2019-05/05/content_32803508.html.

[190] Sebastian Horn, Carmen M. Reinhart, and Christoph Trebesch, "China's Overseas Lending," Working Paper 26050 (Cambridge, MA: National Bureau of Economic Research, 2019).

trends in the role of Chinese smart cities technology in developing and developed countries; discusses future plans and possible trajectories; and closes with a summary of the economic and political implications of these exports for the United States.

By supporting both domestic technological development and international exports and infrastructure projects, the Chinese government has been aiming to become the leading developer and exporter of smart cities technologies and products globally for years already, introducing supportive policies and pilot projects since 2013.[191] The Chinese smart city products and systems involved in projects abroad are not limited to a single technology or industry: analysts identified Chinese exports of telecommunications infrastructure, unified management platforms, e-government systems, and surveillance systems.[192] In order to quantify the breadth of Chinese smart city-enabling technology abroad, analysts first identified the main Chinese companies developing industrial standards for these products domestically and then investigated their activities in other countries.

Taking Smart Cities Abroad: The Belt and Road Initiative, State-Backed Financing, and International Standards Organizations

Chinese policymakers believe that the construction of smart cities is a vital component of China's Belt and Road Initiative (BRI), which provides a "strategic opportunity" for Chinese firms to expand abroad.[193] This pairing of smart cities with the BRI comes from the highest levels of the Chinese government: in a May 2017 speech, Xi Jinping stated that the BRI must "promote big data, cloud computing, and smart city construction."[194] Chinese national-level plans emphasize that BRI investment in smart cities technologies will entail the acquisition of and investment in foreign companies and the establishment of foreign research centers.[195] Although in many cases established specifically to assuage governments' security concerns, Huawei and ZTE have already accomplished this by opening dozens of such research facilities in cities in Central America, Europe, Asia, Africa, and the Middle East that are focused on research and testing of smart grid, IoT, big data, cloud computing, and other smart city technologies.[196] Beyond these general

[191] He Huifeng, "China Poised for Leadership Role in Smart City Technology as Rural to Urban Migration Continues," *South China Morning Post,* November 18, 2015, https://www.scmp.com/tech/china-tech/article/1879927/china-poised-leadership-role-smart-city-technology-rural-urban.

[192] All mentions in this chapter of "smart cities projects" refer to any instances of exported technologies, agreements to install systems or equipment, or collaborations on implementation of smart city-enabling technologies abroad.

[193] "[Cyberspace Administration of China: Sharing the Smart City as an Important Component of BRI] (网信办:将智慧城市共建作为"一带一路"重要内容)," *HC Security Network News 慧聪安防网讯*, April 18, 2016, http://info.secu.hc360.com/2016/04/180933855855.shtml.

[194] Guo Huadong 郭华东, "[Let Science and Technology Innovation Escort 'BRI'] (让科技创新护航'一带一路']," *China Science News 中国科学报*, September 4, 2018, http://www.qstheory.cn/science/2018-09/04/c_1123378950.htm.

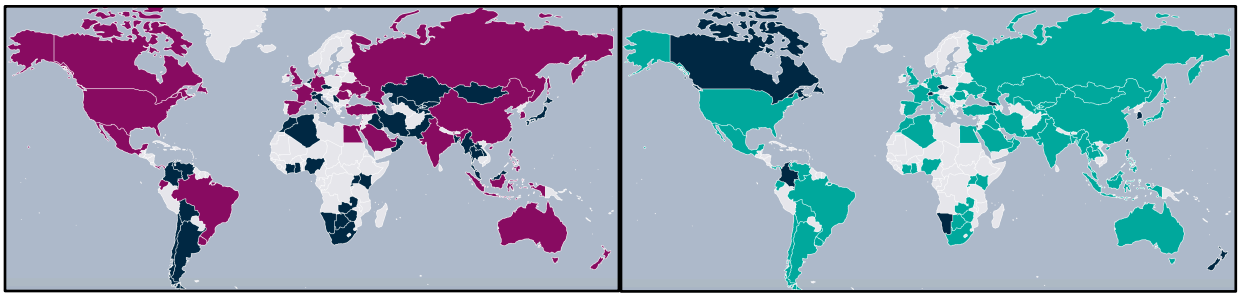
[195] "[State Council Announcement on the Next Generation AI Development Plan] (国务院关于印发新一代人工智能发展规划的通知)," PRC State Council (国务院), July 20, 2017, http://www.gov.cn/zhengce/content/2017-07/20/content_5211996.htm; "[State Council Announcement on the 13th Five Year Plan National Informatization Plan] (国务院关于印发"十三五"国家信息化规划的通知)," PRC State Council (国务院), December 27, 2016, http://www.gov.cn/zhengce/content/2016-12/27/content_5153411.htm.

[196] Huawei, "About OpenLab," accessed November 12, 2019, https://e.huawei.com/en/partner/openlab; Huawei, "OpenLab, Johannesburg," accessed November 12, 2019, https://e.huawei.com/en/partner/openlab/Johannesburg; Huawei, "OpenLab, Munich," accessed November 12, 2019, https://e.huawei.com/en/partner/openlab/munich; Juan Pedro Tomás, "ZTE to Open Three Security Labs during This Year," *RCR Wireless News*, February 27, 2019,

framings of Chinese priorities in smart cities and development partnerships abroad, no top-level guidance from Chinese government organizations could be found that identifies more specific plans on how they intend to further capture the global smart cities market.

Accessible financing has been vital to China's success in marketing smart city technology to the developing world. According to a recently published report by the Carnegie Endowment for International Peace, both the United States and China have successfully found export markets for the AI-driven surveillance technology that is increasingly a key feature of smart cities implementation.[197] However, Chinese companies have sold surveillance technology in a far wider range of countries, especially in the developing world, in part because the projects have been bought on credit. This is illustrated in the two maps below. Out of the countries using any kind of AI surveillance technologies (depicted by default in dark blue, while those not using AI surveillance technologies are in light gray), those purchasing U.S. surveillance technologies are highlighted with a purple overlay on the map to the left, and those purchasing Chinese-made surveillance technologies are highlighted with a green overlay on the map to the right. While many countries are purchasing these technologies from both the United States and China, of the countries that are only purchasing from one or the other, a far greater number are buying from China.

Figure 5: Global Deployment of AI Surveillance Technology
United States (left) and China (right)



Source: Carnegie Endowment for International Peace.[198]

Since both developed and developing nations are looking to build smart cities to increase efficiency as well as improve quality of life for their populations, there is growing demand in many parts of the world for smart cities products. In many middle-income countries like South Africa and Brazil, issues of violent crime overshadow privacy concerns, supporting a growing market for surveillance systems.[199] Although wealthier countries have less interest in Chinese security products, Chinese firms see more developed countries like Germany and South Korea as valuable sources of technology and expertise as well as markets for Chinese technology, frequently

https://www.rcrwireless.com/20190227/5g/zte-open-three-security-labs-during-year; ZTE, "Openlab," accessed 12 November 2019, https://openlab.zte.com.cn/en/aboutopenlab.

[197] Steven Feldstein, "The Global Expansion of AI Surveillance," Carnegie Endowment for International Peace, September 17, 2019, https://carnegieendowment.org/2019/09/17/global-expansion-of-ai-surveillance-pub-79847.

[198] "AI Global Surveillance Technology," Carnegie Endowment for International Peace, https://carnegieendowment.org/publications/interactive/ai-surveillance, companion to Steven Feldstein, "The Global Expansion of AI Surveillance," Carnegie Endowment for International Peace, September 17, 2019, https://carnegieendowment.org/2019/09/17/global-expansion-of-ai-surveillance-pub-79847.

[199] Otavio Veras, "Smart Cities in Africa: Nairobi and Cape Town," *How We Made It in Africa*, April 10, 2017, www.howwemadeitinafrica.com/smart-cities-africa-nairobi-cape-town/58209/.

developing partnerships and establishing joint laboratories in these countries.[200] These partnerships could be used to facilitate technology transfer as well as to encourage foreign firms to conform to Chinese-developed technology standards.

Another route for promoting Chinese standards is through international standard-setting bodies such as ITU, 3GPP, and IEEE. China's active participation in these organizations helps steer the standards-setting process in a direction that is advantageous to Chinese companies, creating a mutually reinforcing system between the volume of its exports and the prominence of its role in the standards process.[201] As in other international technology standards organizations, Chinese delegations have been effective in securing leadership roles, thus gaining an outsized say over the bodies' decision-making processes. For example, although the International Standards Organization/International Electrotechnical Commission Joint Technical Commission 1 (ISO/IEC JTC 1) working group on Smart Cities has 25 member nations, all three of the officers are from China (which has led the group since its inauguration as a Study Group in 2013), and three of the group's ten meetings have taken place in China.[202] It is difficult to measure the impact of this aggressive approach to smart cities-related international standards organizations, as the varied nature of smart cities development and its rollout atop existing municipal and security functions makes fruitful standardization difficult. That said, it is a strategy that has given Chinese exports an advantage in the past and one China can be expected to continue.

Methodology and Study Limitations

No comprehensive database quantifying Chinese smart city projects abroad currently exists. To identify the Chinese companies most likely to be involved in smart cities systems abroad, analysts compiled a list of the most prominent Chinese firms selling smart cities technologies and systems. These Chinese firms were gathered from lists of organizations producing Chinese smart cities industrial standards,[203] partners and members of Chinese smart cities industry alliances and research centers,[204] and entities listed in securities research reports on Chinese smart cities industry

[200] Huawei, "Huawei Opens Its First 5G OpenLab in South Korea, Partnering with Korean SMEs to Build the 5G Ecosystem," press release, June 3, 2019, https://www.globenewswire.com/news-release/2019/06/03/1863641/0/en/Huawei-Opens-Its-First-5G-OpenLab-in-South-Korea-Partnering-with-Korean-SMEs-to-Build-the-5G-Ecosystem.html.

[201] John Chen, Emily Walz, Brian Lafferty, Joe McReynolds, Kieran Green, Jonathan Ray, and James Mulvenon, "China's Internet of Things," Research Report prepared on behalf of the U.S.-China Economic and Security Review Commission, October 2018, https://www.uscc.gov/sites/default/files/SOSi_China%27s%20Internet%20of%20Things_Executive%20Summary.pdf.

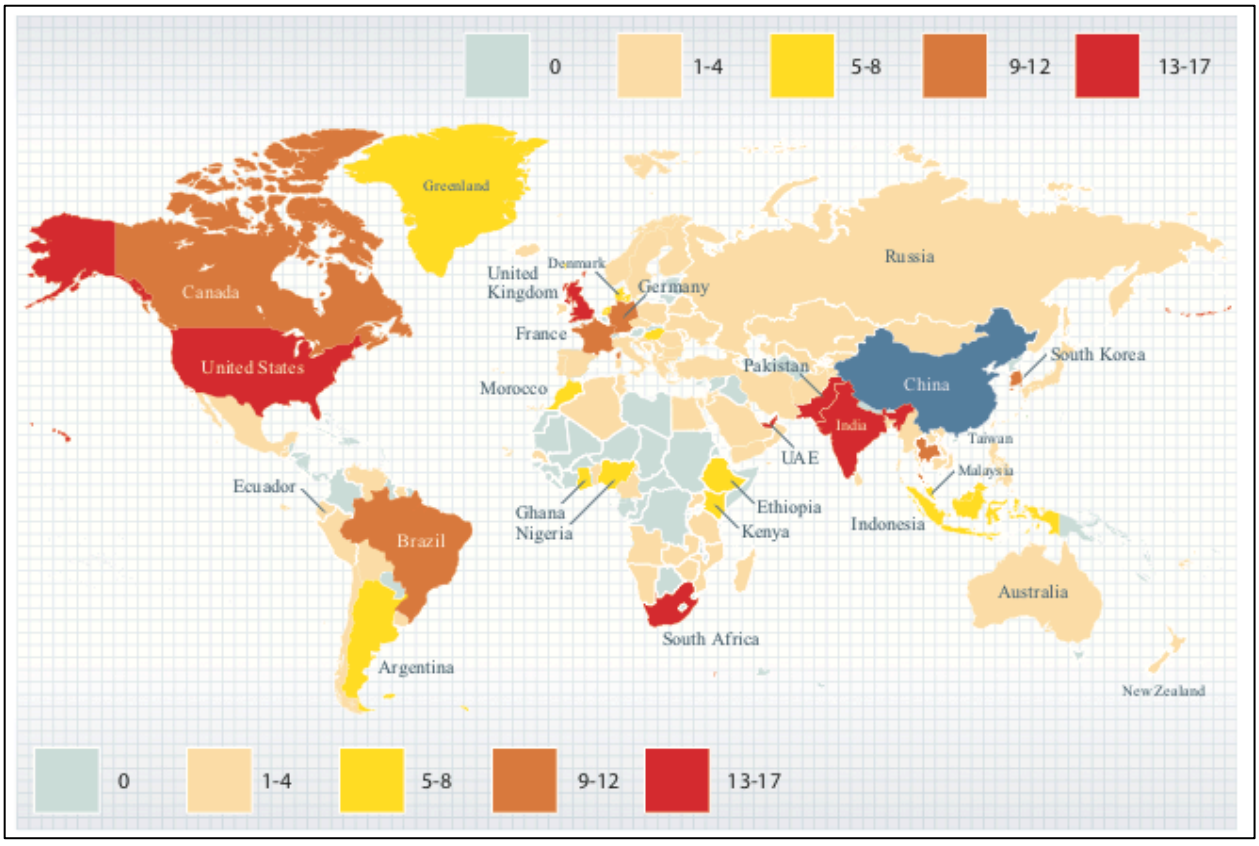
[202] ISO/IEC JTC1, "WG11," August 2018, https://jtc1info.org/sd_2-history_of_jtc1/jtc1-scs-and-groups/wg-11-smart-cities/.

[203] Standardization Administration of the People's Republic of China, "Smart City—Top-Level Design Guide (智慧城市 顶层设计指南 (GB/T 36333-2018))," http://www.std.gov.cn/gb/search/gbDetailed?id=71F772D82E5AD3A7E05397BE0A0AB82A.

[204] "[Enterprise Alliance Group] (企业联合组)," China Smarter City Development and Research Center (中国智慧城市发展研究中心), http://scdrc.sic.gov.cn/Column/342/0.htm/; "[60 Company Introductions] (60 家企业介绍)," [New Smart City Construction Enterprise Alliance] (新型智慧城市建设企业联盟), http://www.eascity.org/alliance-partners/alliance-partners; "[Alliance Members] (联盟成员)," Z-Park Strategic Alliance of Smart City Industrial Technological Innovation (中关村智慧城市产业技术创新战略联盟), http://www.smartcityunion.cn/index.php?m=content&c=index&a=lists&catid=16.

development.[205] Overall, the key Chinese companies interfacing with foreign technology firms through smart cities expos and alliances are well represented within the aforementioned groups. Analysts searched the official websites of each of the 65 companies on this list for reports of smart cities projects in other countries. These searches yielded 398 reported cases of 34 different Chinese firms exporting smart cities technologies through involvement in smart city development projects in a total of 106 countries. An overview of the geographic distribution of these projects is presented in a map in the figure below.

Figure 6: Globally Identified Chinese Smart Cities Projects[206]



Source: Analyst-compiled data set.

The nature of smart city applications itself was a challenge to collecting a uniform data set. Smart city implementation involves multiple discrete products such as servers, surveillance cameras, and sensors can be utilized in smart city applications. Since classifications of "smart cities technologies" can be wide-ranging and inconsistent, the collection of projects abroad in this data set is likely incomplete, but analysts made efforts to be inclusive rather than exclusive. An overview of the products and technologies considered for this effort is provided in the following section. For the compiled dataset, analysts included references to exports that were a part of smart city applications

[205] Ping An Securities (中国平安), "[Report on Smart City Models: Using the Construction of Smart Cities in China to Achieve Security and Stability] (智慧城市系列专题报告新生态、新模式，助力国内新型智慧城市建设行稳致远)," http://finsec.pingan.com/ueditor/net/upload/file/20181018/6367547099712221067431554.pdf.

[206] All territories of countries are shaded to the same level, regardless whether smart cities projects were identified there (e.g., Hawaii, Greenland).

as well as those that had the potential to be used in smart city implementation. Specifically, any project described as involving "smart cities" technology was included, and technologies with established smart cities applications were also included, regardless of whether or not they were described as part of a "smart cities project." For example, surveillance systems deployed in public settings were included regardless of whether or not they were marketed for larger-scale smart cities applications such as unified operations platforms.

Some Chinese companies are more forthcoming about their work abroad than others, resulting in a data set that disproportionately represents those companies. For example, Huawei provides detailed case studies of many of their "success stories," while most information about smart cities infrastructure built by the China Electronics Import & Export Corporation (CEIEC, 中国电子进出口有限公司) has been gathered from third-party sources. In a similar fashion, many of these companies do not specify their projects in sufficient detail to include in this study. In addition, in many cases it is difficult to pinpoint the direct financing of smart cities projects; this has only been specified when it could be confirmed.

Identified Smart City Technology Exports

The smart cities technologies identified in this set of projects fall into the major categories of surveillance, network infrastructure, big data, fintech, integrated platforms, and municipal services (Table 8). Network infrastructure and surveillance technologies have been especially successful exports to BRI countries,[207] in part due to the vast resources that the Chinese government has put into developing these industries domestically. While dozens of Chinese companies are involved with smart cities projects, in this data set, Hikvision and Huawei appear as the largest exporters of relevant products and services with 136 and 56 projects respectively, followed by Dahua and ZTE[208] with 51 and 36 projects. This is consistent with other studies that identify Huawei as one of the most important vendors of smart cities technology globally.[209]

[207] Which countries are "members" of the Belt and Road Initiative rather than just "participants" is somewhat unclear, but there does appear to be a distinction between countries participating in discrete BRI projects and a smaller number of countries that have signed larger agreements to "jointly advance" the BRI (usually described as joining the initiative or agreeing to cooperate under its framework). Chinese sources give only more expansive participant numbers without enumerating how many nations are BRI members. For instance, an October 2019 article counted 130 countries and 29 international organizations that had signed BRI cooperation agreements, drawing from the official government Belt and Road Portal, which gives only the longer list. Reporting on individual countries that have "joined" the BRI uses that language rather than the more general "participating country." Ehizuelen Michael M. O., "The BRI Brings Countries Out of A 'No Development Trap,' Not Into A 'Debt Trap'" CGTN, October 4, 2019, https://news.cgtn.com/news/2019-10-04/The-BRI-is-not-a-debt-trap-and-helps-development--Kw0CxcfzAk/index.html; "[List of Countries That Have Signed a 'One Belt, One Road' Cooperation Document with China] 已同中国签订共建“一带一路”合作文件的国家一览," Belt and Road Portal, https://www.yidaiyilu.gov.cn/info/iList.jsp?cat_id=10037; Weida Li, "Ecuador Joins China's Belt and Road Initiative," December 13, 2018, *Global Times*, https://gbtimes.com/ecuador-joins-chinas-belt-and-road-initiative.

[208] Including ZTE subsidiaries.

[209] Navigant Research, "Navigant Research Leaderboard: Smart City Suppliers," 2017, https://www.navigantresearch.com/reports/navigant-research-leaderboard-smart-city-suppliers.

Table 8: Overview of Identified Chinese Smart Cities Technology Exports

Technology Category	Product Type	Chinese Companies Involved	Present in Case Study
Surveillance	IP cameras, CCTV, DVR, NVR, video management systems, police body cameras, traffic surveillance systems, facial recognition, IR cameras, license plate recognition	Huawei, Hikvision, Dahua, Shenzhen ZNV, Megvii, Kedacom, Cloudwalk, Uniview, E-Hualu, Yitu	Malaysia, Ecuador, Kenya, Germany, United Kingdom
Network Infrastructure	Backbone networks, Wi-Fi, high-speed networks, 3G, 4G, and 5G infrastructure, LTE networks	Huawei, ZTE, H3C	Malaysia, Ecuador, Kenya, Germany, United Kingdom
Big Data	Cloud networks, data centers, servers	Huawei, Alibaba, Tencent, Sugon, Inspur, Sangfor, iSoftStone, ChinaSoft	Malaysia, Germany
Fintech	Mobile payment applications, automated payment systems	Huawei, Ping'an, Panda Electronics	Malaysia, Kenya
Energy	Smart grid, smart meters, advanced metering infrastructure (AMI)	Huawei, ZTE, CEIEC Electric	
Integrated Platforms	Emergency response systems, "safe city" solutions, unified urban operation platforms, command centers, dispatching systems, call centers	Huawei, ZTE, Dahua, Alibaba, Kedacom, Shenzhen ZNV	Malaysia, Ecuador, Kenya, Germany
Municipal Services	Smart parking, traffic management and control systems, bus system, smart streetlamps, smart waste management	Huawei, Hikvision, Dahua, Kedacom Gosuncn, E-Hualu, Panda Electronics, Founder International, Carsmart, TelChina, Shenzhen ZNV, iSoftStone	Malaysia, Kenya, Germany, United Kingdom

Looking at Chinese smart cities technologies, it is clear that a wide range of countries see Chinese smart cities offerings as desirable solutions to domestic urban security, transportation, and infrastructure challenges. The breadth of projects that could be identified shows how well Chinese firms have met this demand. From the set of smart cities projects, analysts selected five countries as case studies: Malaysia, Ecuador, Kenya, the United Kingdom, and Germany. These countries were chosen to be representative of multiple stages of economic development, types of smart cities technologies provided, and existing Chinese investment. Each of these five countries were found to have imported Chinese surveillance equipment and network infrastructure. In general, developing nations (Malaysia, Ecuador, and Kenya) are more likely to be collaborating with China on unified security management smart cities projects, while developed nations (United Kingdom) have more partnerships with Chinese companies to provide ICT infrastructure, security cameras, and intelligent municipal services. Germany is the exception to this trend and has involved Chinese companies in projects implementing integrated smart city platforms in addition to network infrastructure and surveillance cameras. The broad correlation between levels of economic development and choice of smart cities projects provides an indication of which technology areas Chinese companies might be likely to target when doing business in any given country.

Case Study: Smart City Platforms in Malaysia

To keep pace with an increasing population and level of urbanization, the Malaysian government has begun exploring smart cities initiatives. Malaysia's top trading partner is China;[210] as a participant in BRI projects and a target nation for encouraging BRI trade as part of the "China Indochina Peninsula Economic Corridor,"[211] it is perhaps unsurprising that Malaysia has partnered with several Chinese technology providers to install smart cities technologies (Table 9), including surveillance systems, ICT infrastructure, and smart traffic management platforms. As with Chinese banks' involvement in smart cities projects in other countries,[212] at least one planned smart city project in Malaysia is funded by a Chinese state-backed financial institution: China Construction Bank's plan to finance a Malaysian government-planned Labuan smart city project.[213] While few Malaysian smart city development efforts can be definitely tied to Chinese state-owned banks, these institutions have in the past supplied loans to Malaysia for infrastructure projects, making it likely that they are also financing a proportion of these smart city projects.[214]

Table 9: Chinese Smart Cities Projects Identified in Malaysia

Company	Technology Category	Location	Projects and Products
Huawei[215]	Network Infrastructures	Sabah	"Smart State"
ZTE[216]	Network Infrastructure	[Unspecified]	5G R&D
Alibaba (Aliyun)[217]	Big Data Integrated Platform	Kuala Lumpur	ET City Brain

[210] "Exporting to Malaysia - Market Overview," Export.gov, August 19, 2019, https://www.export.gov/article?id=Malaysia-Market-Overview.

[211] "Malaysia Seeks Greater Cooperation with China to Boost Railway Industry," Xinhua, January 3, 2019, http://www.xinhuanet.com/english/2019-01/03/c_137717280.htm; "Malaysia Says It Stands to Reap Benefits from Belt and Road Initiative," Xinhua, October 27, 2019, news.xinhuanet.com/english/2017-10/27/c_136710199.htm; "[Speech by Lu Shizhen, Consul General of Penang, at the Inauguration Ceremony of the 'Belt and Road' Research Center in Malaysia] 驻槟城总领事鲁世巍在马来西亚'一带一路'研究中心成立仪式上的致辞,'" Ministry of Foreign Affairs of the People's Republic of China, July 30, 2019, https://www.fmprc.gov.cn/web/dszlsjt_673036/t1684403.shtml.

[212] Shunsuke Shigeta, "Thai 'Smart City' to be First of 50 Japan-China Joint Projects," *Nikkei Asian Review*, October 25, 2018, https://asia.nikkei.com/Politics/International-relations/Thai-smart-city-to-be-first-of-50-Japan-China-joint-projects.

[213] Jailani Hasan, "China Construction Bank Keen to Finance Labuan Bridge, Smart City," *Bernama*, October 25, 2019, http://www.bernama.com/en/news.php?id=1783067.

[214] OECD, "China's Belt and Road Initiative in the Global Trade, Investment and Finance Landscape," 2018, https://www.oecd.org/finance/Chinas-Belt-and-Road-Initiative-in-the-global-trade-investment-and-finance-landscape.pdf.

[215] "Huawei Launches Smart City Solutions," *Enterprise IT News*, May 24, 2015, http://www.enterpriseitnews.com.my/huawei-launches-smart-city-solutions-for-malaysia/; Steve Rogerson, "Huawei to Help Sabah in Malaysia Become Smart State," IoT M2M Council, March 8, 2016, https://www.iotm2mcouncil.org/huasab; "Huawei Announces New OpenLab in Malaysia to Drive Digital Transformation in APAC," Huawei, November 9, 2017, https://www.huawei.com/ch-en/press-events/news/2017/11/Huawei-New-OpenLab-Malaysia-APAC.

[216] Lee Kah Leng, "Smart City and 5G Technology Key Drivers for ZTE in Malaysia," *The Star Online*, October 29, 2015, https://www.thestar.com.my/tech/tech-news/2015/10/29/zte-wireless-broadband-forum-2015/.

[217] Lin Rui 林林芮, "[Chinese Business to Help Malaysia Create Smart City] (中企助力马来西亚打造智慧城市)," *People's Daily 人民日报*, February 24, 2018, http://paper.people.com.cn/rmrb/html/2018-

	Municipal Services		
Hikvision[218]	Surveillance	Kuala Lumpur	Public Space Surveillance Systems
Dahua[219]	Surveillance	[Unspecified]	Public Space Surveillance Systems
Ping An[220]	Fintech Integrated Platform Big Data Municipal Services	[Unspecified]	"N+1" Smart City Platform Blockchain-based ledgers Integrated government services app
Megvii[221]	Surveillance	[Unspecified]	[Unspecified]
Yitu[222]	Surveillance	[Unspecified]	Facial Recognition-Enabled Police Body Cameras
Carsmart[223]	Municipal Services	Kuala Lumpur	Smart Parking

The most prominent example of a Chinese smart cities system deployed in Malaysia is Alibaba's integrated smart city platform. In January 2018, Alibaba's cloud computing brand Aliyun (阿里云, or Alicloud) announced plans to make Kuala Lumpur an implementation site for their "ET City Brain" (ET 城市大脑) smart city solution, the first deployment of the product outside of China.[224]

02/24/nw.D110000renmrb_20180224_1-11.htm; Jon Russel, "Malaysia's Capital Will Adopt 'Smart City' Platform from Alibaba," *TechCrunch*, January 29, 2018, https://techcrunch.com/2018/01/29/malaysia-alibaba-city-brain/; "[Alibaba 'Smart City' Experiment Abroad, Malaysia Uses AI-Improved City] (阿里云"城市大脑"试水海外，马来西亚用 AI 改善城市]," *Iyiou.com*, January 31, 2018, https://www.iyiou.com/p/65545.html; Zunaira Saieed, "Kuala Lumpur Set to Become Smart City Next Year," *The Star Online*, April 25, 2019, https://www.thestar.com.my/business/business-news/2019/04/25/kuala-lumpur-set-to-become-smart-city-next-year/.

[218] "Hikvision's High-end Quality and Variety Make a Difference in Malaysia," Hikvision, February 16, 2012, https://www.hikvision.com/europe/News--Events/Success-Stories/Education/305528883696866; "[U.S. Department of Commerce to Seal Off Technology Businesses: Hikvision, Dahua Prohibited Conclusively] (美国商务部技术封锁企业: 海康、大华被禁已成定局)," https://m.ydaobo.com/wenzhang/15044.html.

[219] Zhejiang Dahua Technology Co. Ltd., "[Dahua Technology Co. Ltd. 2018 Annual Report] (浙江大华技术股份有限公司 2018 年年度报告全文)," March 2018, https://www.dahuatech.com/upload/2019/03/21/15531453979753snz9n.pdf.

[220] Wang Gang 王刚, "[Exclusive Interview with Ping An Smart CEO Yu Taiwei: Ping An Group's City Services Five Core Strategies Explained] (专访平安智慧 CEO 俞太尉：详解平安集团五大核心战略中的城市业务)," Leiphone 雷锋网, March 22, 2019, https://www.leiphone.com/news/201903/gpMW0V1nZnL8wmLn.html; Huawei, "[Malaysia Communications Minister 'Likes' Huawei Safe City] (马来西亚通信部长为华为平安城市"点赞), May 29, 2015, *Asmag.com* (安防知识网), http://security.asmag.com.cn/news/201505/79558.html.

[221] Sarah Dai, "Tech Start-Ups Push to Make China's Facial Recognition Systems Part of Daily Life across Asia," July 3, 2018, *The Star Online,* https://www.thestar.com.my/tech/tech-news/2018/07/03/tech-startups-push-to-make-chinas-facial-recognition-systems-part-of-daily-life-across-asia/.

[222] "[Cases] (行业实践)," Yitu Technology, https://www.yitutech.com/en/cases?case_type_tid=16; Sarah Dai, "Tech Start-ups Push to Make China's Facial Recognition Systems Part of Daily Life across Asia," July 3, 2018, *The Star Online*, https://www.thestar.com.my/tech/tech-news/2018/07/03/tech-startups-push-to-make-chinas-facial-recognition-systems-part-of-daily-life-across-asia/.

[223] Zeng Jian 曾剑, "[UEC Group Will Participate in Malaysia Smart City Project] (荣之联将参与马来西亚智慧城市项目)," *National Business Daily 每日经济新闻*, December 14, 2017, http://www.nbd.com.cn/articles/2017-12-14/1171552.html.

[224] Lin Rui 林林芮, "[Chinese Business to Help Malaysia Create Smart Cities] (中企助力马来西亚打造智慧城市)," *People's Daily 人民日报*, February 24, 2018, http://paper.people.com.cn/rmrb/html/2018-02/24/nw.D110000renmrb_20180224_1-11.htm; "[Malaysia Announces Introduction of Alibaba ET City Brain: for Kuala Lumpur Traffic] (马来西亚宣布引入阿里云 ET 城市大脑: 为吉隆坡治堵)," *Tech.163.com 网易科技报道*, January 29, 2018, http://tech.163.com/18/0129/15/D9B373JT00097U7R.html; Jon Russel, "Malaysia's Capital Will Adopt 'Smart City' Platform from Alibaba," *TechCrunch*, January 29, 2018, https://techcrunch.com/2018/01/29/malaysia-alibaba-city-brain/.

ET City Brain is an integrated AI-enabled system utilizing Alibaba's Apsara cloud computing platform[225] that conducts real-time data collection and integration of traffic and emergency response data from hundreds of traffic cameras and other sources.[226] The system aims to improve the efficiency of traffic flow and influences traffic signal timing to allow for emergency vehicle passage.[227] Malaysian news sources indicate plans to implement this system in other Malaysian cities.[228] Alibaba's project came after Malaysia established a digital free trade zone for e-commerce[229] and a data center in Kuala Lumpur in 2017, providing computing power for Alibaba to leverage in establishing this big data platform.[230] Alibaba has played a role in other smart cities-enabling technology cultivation efforts in Malaysia—the Malaysia Tianchi Big Data Program was designed to identify startups with technologies to solve large-scale technical challenges in Malaysia.[231]

The Malaysian government has also been working closely with Huawei to develop smart cities technologies and build ICT infrastructure.[232] Huawei has provided training, products, and services to Malaysia since 2011[233] and has been advertising its smart cities solutions to Malaysia since 2015.[234] Since inadequate infrastructure was previously a barrier to the implementation of smart

[225] "Apsara Stack," Alibaba Cloud, https://www.alibabacloud.com/product/apsara-stack.
[226] "[ET City Brain] (ET 城市大脑)," Alibaba Cloud, https://et.aliyun.com/brain/city; Barbara Szewcow and Jonathan Andrews, "Kuala Lumpur to Build 'City Brain' with Alibaba Cloud," *ITU News*, February 14, 2018, https://news.itu.int/kuala-lumpur-manage-city-data-alibaba-cloud/; "[Chinese AI Helps Kuala Lumpur Traffic, 'AI Already Can Do Everything'] (中国 AI 帮吉隆坡治堵，网友评"人工智能已经无所不能)," *Toutiao 每日头条*, January 18, 2018, https://kknews.cc/zh-sg/news/gzezoly.amp; "Alibaba's Wanli Min Presents 'City Brain' and Talks Upcoming Quarterly Results," *Euronews*, October 19, 2018, https://www.euronews.com/2018/10/19/alibaba-s-wanli-min-presents-city-brain-and-talks-upcoming-quarterly-results.
[227] "MDEC and Alibaba Gives the City A 'Brain,'" *Business Today*, January 29, 2018, https://www.businesstoday.com.my/2018/01/29/mdec-and-alibaba-gives-the-city-a-brain/.
[228] Bernama, "Alibaba's City Brain to Be Implemented in Other Parts of M'sia," *Malaysiakini*, September 20, 2018, https://www.malaysiakini.com/news/443936.
[229] Eva Xiao, "Alibaba Doubles down on Malaysia, Rolls out Traffic Control System," Tech in Asia, January 28, 2019, https://www.techinasia.com/malaysia-city-brain; Steven Millward, "Jack Ma Opens Malaysia's 'Digital Free Trade Zone' with An Eye to Southeast Asia's Ecommerce Boom," November 3, 2017, *Tech in Asia*, https://www.techinasia.com/jack-ma-opens-malaysias-digital-free-trade-zone-eye-southeast-asias-ecommerce-boom.
[230] Barbara Szewcow and Jonathan Andrews, "Kuala Lumpur to Build 'City Brain' with Alibaba Cloud," *ITU News*, February 14, 2018, https://news.itu.int/kuala-lumpur-manage-city-data-alibaba-cloud/; "[Alibaba Cloud Will Add New Malaysia's Data Center, Expedited to Arrange for Cloud Computing] (阿里云将增设马来西亚数据中心 加速布局云计算)," *Netease 网易科技报道*, May 12, 2017, http://tech.163.com/17/0512/15/CK8EH03400097U7R.html.
[231] "Alibaba Cloud Launches Malaysia City Brain to Enhance City Management," Alibaba Cloud, January 29, 2018, https://www.alibabacloud.com/press-room/alibaba-cloud-launches-malaysia-city-brain-to-enhance-city-management.
[232] "Huawei Gains Support in Malaysia," *The Star Online*, June 4, 2019, https://www.thestar.com.my/tech/tech-news/2019/06/04/huawei-gains-support-in-malaysia/; "Mahathir Says Malaysia Will Use Huawei 'As Much As Possible,'" *Channel News Asia*, May 30, 2019, https://www.channelnewsasia.com/news/business/mahathir-says-malaysia-will-use-huawei-as-much-as-possible-11579736.
[233] "[Malaysia] (马来西亚)," Huawei, https://www.huawei.com/cn/about-huawei/sustainability/win-win-development/social-contribution/seeds-for-the-future/Malaysia; Sharmine Ishak, "Huawei Launches Malaysia Global Training Center to Cultivate ICT Talent," *Malaysia Hardware Zone*, June 18, 2012, https://www.hardwarezone.com.my/tech-news-huawei-launches-malaysia-global-training-center-cultivate-ict-talent.
[234] "Huawei Launches Smart City Solutions," *Enterprise IT News*, May 24, 2015, http://www.enterpriseitnews.com.my/huawei-launches-smart-city-solutions-for-malaysia/.

cities solutions in Malaysia,[235] Huawei partnered with local telecommunications companies and developed opportunities for technology exchange to help upgrade Malaysia's telecommunications infrastructure. Significant progress began in 2013 when Huawei constructed an office and data center in Iskandar[236] and has expanded in the years since to encompass state- and province-level cooperative agreements. In March 2016, Huawei signed a Memorandum of Understanding (MoU) with the Sabah state government to provide ICT equipment, which would ultimately be the backbone for any future smart cities infrastructure.[237] In September 2017, Huawei signed an MoU with the central Malaysian government to develop public security and smart cities solutions for Malaysian cities.[238] Later that fall, Huawei also announced plans to establish a smart cities laboratory in Kuala Lumpur to facilitate the exchange and implementation of these technologies.[239] It is likely that Chinese technology firms' presence in Malaysia will continue to grow, and with it the amount of Chinese-built smart cities infrastructure.

Case Study: Integrated Security Platforms in Ecuador

Ecuador, which has historically enjoyed strong trade ties with China and benefitted from significant Chinese lending,[240] officially joined the BRI in December 2018. This official accession (as opposed to merely participating in BRI-affiliated projects) makes it the most closely tied to the BRI of the countries examined in this chapter's case studies and is reflective of a generally close relationship between China and Ecuador. China is Quito's largest lender,[241] and major state-owned entities such as the China Road and Bridge Corporation (CRBC, 中国路桥工程有限责任公司), CEIEC, and China Exim Bank all have a long-standing presence in Ecuador, particularly in the realm of infrastructure construction.[242] As in many markets around the world, Huawei and ZTE are the dominant suppliers serving Ecuador's telecommunications firms (see Table 10).[243]

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[235] Azizul Rahman Ismail, "Huawei to Enable Smart Cities and Host Content in Malaysia," *Malaysia Hardware Zone*, May 19, 2015, https://www.hardwarezone.com.my/tech-news-huawei-enable-smart-cities-and-host-content-malaysia.

[236] Penny Jones, "Huawei to Build Malaysia Data Center," *Data Center Dynamics*, October 7, 2013, https://www.datacenterdynamics.com/news/huawei-to-build-malaysia-data-center/.

[237] "[Malaysia Sabah Government will Collaborate with Huawei to Build Regional ICT Center] (马来西亚沙巴州政府携手华为打造区域 ICT 中心)," Huawei, March 2, 2016, https://www.huawei.com/cn/press-events/news/2016/3/regional-ICT-hub.

[238] Bernama, "MIMOS-Huawei Smart Initiative to Address Public Safety, Smart City Issues," *New Straits Times,* October 18, 2017, https://www.nst.com.my/business/2017/10/292310/mimos-huawei-smart-initiative-address-public-safety-smart-city-issues.

[239] Huawei, "Huawei Announces New OpenLab in Malaysia to Drive Digital Transformation in APAC," November 9, 2017, https://www.huawei.com/en/press-events/news/2017/11/Huawei-New-OpenLab-Malaysia-APAC.

[240] Kevin Koening, "Amazon Threatened by China-Ecuador Loans for Oil," China Dialogue, July 3, 2017, https://www.chinadialogue.net/article/show/single/en/9651-Amazon-threatened-by-China-Ecuador-loans-for-oil.

[241] Conference Proceedings, Third Yale Symposium on Chinese Overseas Investment Impacts held January 25, 2019 (New Haven: Yale School of Forestry and Environmental Studies: April 2019), https://china-symposium.yale.edu/sites/default/files/2019-bri-conference-proceedings_final_4.23.pdf.

[242] Cao Jianing 曹家宁, "Xi Welcomes Ecuador to Help Build Belt, Road," Yidaiyulu.gov.cn, December 13, 2018, eng.yidaiyilu.gov.cn/qwyw/rdxw/74589.htm; Cao Jianing 曹家宁, "China's BRI Provides Development Opportunity for Ecuador," Yidaiyilu.gov.cn, April 10, 2019, https://eng.yidaiyilu.gov.cn/gbjg/gbgk/74636.htm.

[243] R. Evan Ellis, "Ecuador's Leveraging of China to Pursue an Alternative Political and Development Path," *Journal of Indo-Pacific Affairs* (Fall 2018), https://www.airuniversity.af.edu/Portals/10/JIPA/journals/Volume-01_Issue-1/07-F-Ellis.pdf.

Table 10: Chinese Smart City Projects in Ecuador

Company	Technology Category	Location	Projects and Products
Huawei[244]	Network Infrastructure Surveillance Integrated Platform	Quito	ECU911 Integrated Security Service
		Guayaquil	
		Cuenca	
		Nationwide	Backhaul Network Infrastructure
ZTE[245]	Network Infrastructure	Nationwide	Backhaul Network Infrastructure
CEIEC[246]	Surveillance Integrated Platform	Quito	ECU911 Integrated Security Service
		Guayaquil	
		Cuenca	
Gsafety[247]	Surveillance Integrated Platform	Quito	ECU911 Integrated Security Service
		Guayaquil	
		Cuenca	

China's most prominent smart cities project in Ecuador is the ECU911 Integrated Security Service. This project, developed from 2011 to 2015, was designed and built by CEIEC. It is described by the director of policy research at the China Electronics Corporation (CEC, 中国电子信息产业集团), the state-owned defense conglomerate that owns CEIEC,[248] as a "networked command system" (网络指挥系统) for police, military, and first responders, made up of an integrated alarm system, intelligent analysis module system, video monitoring system, GPS positioning system, GIS map system, and one-button alarm system. CEC says the goal of ECU911 is to integrate alarms and video surveillance across the country to provide a unified national security system and integrate the resources of the state to realize effective emergency response.[249] CEC claims that following the installation of this system, 92 percent of calls can be responded to within four seconds and that

[244] Huawei, "Wi-Fi Network Upgrades Quito Transit"; Li Lei 李蕾 and Du Changzheng 杜长征, "[The 'Belt and Road Initiative' in Practice: Creating a National Business Card for Information Technology 'Going Out'] (践行"一带一路 " 倡议打造信息化能力"走出去"国家名片)," in *Reform and International Competitiveness of State-owned Enterprises - Leaders Narration (国有企业改革与 国际克争力—领导者的讲述)*, by Lu Mai 卢迈 (Beijing: Social Sciences Academic Press (China) (社会科学文献出版社), 2017), 202-209.

[245] R. Evan Ellis, "Ecuador's Leveraging of China to Pursue an Alternative Political and Development Path," *Journal of Indo-Pacific Affairs* (Fall 2018), https://www.airuniversity.af.edu/Portals/10/JIPA/journals/Volume-01_Issue-1/07-F-Ellis.pdf.

[246] Li Lei 李蕾 and Du Changzheng 杜长征, "[The 'Belt and Road Initiative' in Practice: Creating a National Business Card for Information Technology 'Going Out'] (践行"一带一路 " 倡议打造信息化能力"走出去"国家名片)," in *Reform and International Competitiveness of State-owned Enterprises - Leaders Narration (国有企业改革与 国际克争力—领导者的讲述)*, by Lu Mai 卢迈 (Beijing: Social Sciences Academic Press (China) (社会科学文献出版社), 2017), 202-209.

[247] "ECU-911," Gsafety, December 17, 2016, http://global.gsafety.com/list/post/30616/.

[248] CEC, "[Job Offers] 招聘信息," http://www.cec.com.cn/zpxx/2018/1010/8ac085c2660d865501665c8daa0d002b.html.

[249] Li Lei 李蕾 and Du Changzheng 杜长征, "[The 'Belt and Road Initiative' in Practice: Creating a National Business Card for Information Technology 'Going Out'") (践行"一带一路 " 倡议打造信息化能力"走出去"国家名片]," in *Reform and International Competitiveness of State-owned Enterprises - Leaders Narration (国有企业改革与 国际克争力—领导者的讲述)*, by Lu Mai 卢迈 (Beijing: Social Sciences Academic Press (China) (社会科学文献出版社), 2017), 202-209.

there has been a 24 percent reduction in crime rates over an unspecified period,[250] though a *New York Times* investigation has disputed the effectiveness of the system.[251]

This project illustrates the close collaboration between China and Ecuador on surveillance technology, a relationship that may allow China access to additional data sets. Chinese technicians work alongside Ecuadorian personnel in ECU911's headquarters in Quito.[252] In the process of establishing ECU911, two delegations traveled from Ecuador to surveillance laboratories in China, and CEIEC established the Laboratory for Comprehensive Security Systems within the Quito headquarters of ECU911. This lab houses ten Chinese CEIEC researchers and technicians and reportedly develops new security programs for ECU911, including a "Mobile Locator" program designed to provide Ecuadorian police with the capability to geolocate any mobile device.[253] In 2016, a deputy director of the ECU911 Integrated Security Service announced that ECU911's 3,500 cameras would have access to facial recognition technology,[254] and the Chinese embassy provided $15.4 million in equipment to support license plate recognition capability.[255]

Ecuador is moving to implement further smart cities initiatives in the future, which are likely to rely on imported technology. The mayor of Quito has announced a public biometric facial recognition initiative as part of its 2018–2021 e-government plan.[256] Though the extent to which this plan will utilize Chinese technology has not been announced, Ecuador will likely continue to be receptive to the surveillance offerings of CEIEC and Chinese firms like it.

Case Study: Surveillance and Smart Payment Systems in Kenya

Chinese companies have rushed to build infrastructure in Africa, and Kenya has been one of the most important recipients of their attention. China is Kenya's largest external creditor and top trade partner[257] and Chinese firms have built a variety of big projects in Kenya, including electric power

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[250] Li Lei 李蕾 and Du Changzheng 杜长征, "[The 'Belt and Road Initiative' in Practice: Creating a National Business Card for Information Technology 'Going Out'] (践行'一带一路'倡议打造信息化能力'走出去'国家名)," in *Reform and International Competitiveness of State-owned Enterprises – Leaders Narration (国有企业改革与国际克争力—领导者的讲述)*, by Lu Mai 卢迈 (Beijing: Social Sciences Academic Press (China) (社会科学文献出版社), 2017), 202-209.

[251] Paul Mozur, Jonah M. Kessel, and Melissa Chan, "Made in China, Exported to the World: The Surveillance State," *New York Times*, April 24, 2019, https://www.nytimes.com/2019/04/24/technology/ecuador-surveillance-cameras-police-government.html/.

[252] "Chinese Technology Saves Lives in Ecuador," *China Daily 中国日报*, April 22, 2016, http://www.chinadaily.com.cn/world/2016-04/22/content_24892566.htm.

[253] Elena Chuquimarca, "[Special: Laboratory with Chinese Technology Contributes to Citizen Security in Ecuador] (ESPECIAL: Laboratorio con tecnología china contribuye a seguridad ciudadana en Ecuador)," Xinhua, January 19, 2018, 67panish.xinhuanet.com/2018-01/19/c_136906504.htm.

[254] "[#Digital Alert EC #Ecuador 3,500 ECU911 Cameras Would Have Facial Recognition] (#AlertaDigitalEC #Ecuador 3,500 cámaras del ECU911 tendrían reconocimiento facial)," *Usauarios Digitales*, November 11, 2016, http://www.usuariosdigitales.org/2016/11/11/alertadigitalec-ecuador-3500-camaras-del-ecu911-tendrian-reconocimiento-facial/.

[255] Charles Rollet, "Ecuador's All-Seeing Eye Is Made in China," *Foreign Policy*, August 9, 2018, https://foreignpolicy.com/2018/08/09/ecuadors-all-seeing-eye-is-made-in-china/.

[256] Chris Burt, "Quito to launch facial recognition for public surveillance under smart city project", August 1, 2019, https://www.biometricupdate.com/201908/quito-to-launch-facial-recognition-for-public-surveillance-under-smart-city-project.

[257] David Herbling and Dandan Li, "China's Built a Railroad to Nowhere in Kenya," Bloomberg, July 17, 2019, https://www.bloomberg.com/news/features/2019-07-19/china-s-belt-and-road-leaves-kenya-with-a-railroad-to-nowhere; Otiato Guguyu, "Focus Shifts to Kenya, China Trade Terms as Imbalance Persists," Business Daily,

infrastructure, port facilities, and highways.[258] Chinese sources refer to Kenya as an "active participant" in the BRI.[259] One of the highest-profile Chinese infrastructure construction projects in East Africa touted as a BRI centerpiece has been the Standard Gauge Railway between Nairobi and Mombasa,[260] a project funded with $3.2 billion USD in loans paid from the state-owned China Exim Bank to the state-owned CRBC to build the railway.[261] Recognizing the questionable commercial viability of some of its BRI loans, China announced it was withholding funding for the remainder of the railway in 2019. Kenya's debt to China has grown at such a high pace (nominal $400 billion USD in 2011 up to nominal $4.7 trillion USD in 2017)[262] that the Chinese ambassador had to publicly state that China would not seize control of a Kenyan port as a result of infrastructure-driven loans.[263]

Chinese technology firms have not been left out of this debt-fueled boom. Numerous Chinese tech firms have launched notable smart cities projects in Kenya, headlined by Huawei's development of Nairobi's "Safe City" system (see Table 11).[264]

Table 11: Chinese Smart Cities Projects in Kenya

Company	Technology Category	Location	Projects and Products
Huawei[265]	Surveillance, Fintech, Big Data, Network Infrastructure, Integrated Platform	Nairobi	Nairobi Surveillance System, Hospital Teleconferencing and Data Management Software
		Nationwide	M-PESA Mobile Payments
		Konza	Konza Smart City Data Center

October 14, 2019, https://www.businessdailyafrica.com/datahub/China-trade-terms-as-imbalance-persists/3815418-5310446-d92n46z/index.html.

[258] Deloitte, "Africa Construction Trends Report 2018," 2018, www2.deloitte.com/cn/en/pages/international-buisness-support/articles/2018-africa-construction-trends-report.html; Kimani Chege, "Top 5 Chinese Funded Projects in Kenya That Are The Real Deal," *The Exchange*, November 22, 2018, https://theexchange.africa/top-5-chinese-funded-projects-in-kenya-that-a-real-deal/; "Chinese Contractor to Complete First Berth of Kenya's Lamu Port in Mid 2018," *China Daily*, April 7, 2017, http://www.chinadaily.com.cn/business/2017-04/07/content_28831548.htm.

[259] "Kenya Is Realizing the Benefits of BRI: Minister," *Global Times*, June 25, 2019, http://www.globaltimes.cn/content/1155679.shtml.

[260] David Herbling and Dandan Li, "China's Built a Railroad to Nowhere in Kenya," Bloomberg, July 17, 2019, https://www.bloomberg.com/news/features/2019-07-19/china-s-belt-and-road-leaves-kenya-with-a-railroad-to-nowhere; "[Special Envoy of President Xi Jinping and State Councilor Wang Yong Attended Mombasa-Nairobi Railway Opening Ceremony] 习近平主席特使、国务委员王勇出席肯尼亚蒙内铁路通车仪式," Xinhua, May 31, 2015, http://www.xinhuanet.com//world/2017-05/31/c_1121064853.htm.

[261] "Standard Gauge Plans on Hold in Kenya," *Railway Gazette*, May 15, 2019, www.railwaygazette.com/news/infrastructure/single-view/view/standard-gauge-plans-on-hold-in-kenya.html.

[262] National Treasury, Republic of Kenya National Treasury, "Statistical Annex to the Budget Statement for the Fiscal Year 2018/2019," June 14, 2018, Africacheck.org/wp-content/uploads/2018/08/Statistical-Annex-to-the-budget-statement-for-the-fiscal-year-2018-2019.pdf.

[263] "[Chinese Ambassador to Kenya Stressed That No Country Has Fallen into A Debt Crisis Because of Cooperation with China] (中国驻肯尼亚大使强调没有一个国家因为与中国合作而陷入债务危机)," China-Africa Friendly Economic and Trade Development Foundation 中非友好经贸发展基金会, May 23, 2019, www.chnafrica.org/cn/fzgl/17202.html.

[264] "Kenya Secures $666 Million from China for Tech City, Highway," Reuters, April 26, 2019, https://www.reuters.com/article/us-kenya-china/kenya-secures-666-million-from-china-for-tech-city-highway-idUSKCN1S21KG.

[265] Otavio Veras, "Smart Cities in Africa: Nairobi and Cape Town," *How We Made It in Africa*, April 10, 2017, www.howwemadeitinafrica.com/smart-cities-africa-nairobi-cape-town/58209/; "Huawei Smart City Brochure," Huawei, July 27, 2017, https://e.huawei.com/en/material/industry/smartcity/fa01438ad7df46419a37edafaba1a788.

Hikvision[266]	Surveillance	Nairobi	Public Space Surveillance Systems
Dahua[267]	Surveillance	Nairobi	Public Space Surveillance Systems
E-Hualu[268]	Municipal Services	Nairobi	Kenya Intelligent Traffic Signal System

Huawei has had a significant presence in Kenya since 2002 and is the largest supplier of ICT equipment to Safaricom, a subsidiary of Vodafone and the dominant telecommunications firm in the country.[269] Huawei's collaboration with Safaricom has coincided with the massive growth of the ICT sector in both Kenya specifically and in sub-Saharan Africa overall. In 2005, only 13.5 per 100 people were mobile phone subscribers, but a decade later, more than 4 out of 5 Kenyans had access to mobile communications.[270] This "informatization" has enabled smart city technologies to grow in a country many may not think of as a driver of technology innovation, and Chinese technology firms have been deeply involved in that evolution.

A perfect example of the rapid deployment of information technologies in Kenya is the growth of mobile payments technology. In 2007, Safaricom established the M-PESA system, a mobile money system that allows people to transfer money or pay bills using their cell phones. By 2017, more than 58 percent of Kenyans used a mobile payment system to transfer money[271] and there were 40 times more M-PESA agents in Kenya than ATMs.[272] In 2015, when Safaricom decided to move the infrastructure supporting M-PESA from Germany to Kenya, Huawei provided the new system.[273] Moreover, M-PESA was adopted as a supported payment method by the Chinese mobile commerce platforms WeChat in 2018[274] and AliExpress in 2019,[275] further drawing Kenya's ICT network into China's growing smart cities ecosystem.

Concerns about the affordability of Kenya's debt to China have reduced the ambitions of some Chinese projects in the east African nation, but one project that appears to be proceeding is the Konza Technology City. In 2019, Kenyan President Uhuru Kenyatta secured a $173 million USD loan for a data center in the planned smart city. The development of this 5,000-acre former cattle

[266] "Nairobi Supermarket Chain Food Plus Gets Fresh Surveillance and Top-Choice Centralized Security," Hikvision, September 4, 2018, www.hikvision.com/europe/Press/Success-Stories/Retail/Nairobi-Supermarket-Chain-Food-Plus-Gets-Fresh-Surveillance-and-Top-Choice-Centralized-Security.
[267] "[Relying on Location, Zhejiang in Kenya] (依靠本土化，浙商在肯尼亚做得风生水起)," *Hangzhou.com.cn 杭州网*, December 8, 2018, http://hznews.hangzhou.com.cn/jingji/content/2018-12/08/content_7111079.htm.
[268] "Traffic Signal Control Solution," E-Hualu, May 12, 2017, http://www.ehualu.com/en/Article/index/id/834/aid/1245.
[269] Gertrude Wangare, "Huawei and Safaricom Mark A 14-Year Anniversary by Offering a 10% Discount on Select Devices," *MobiTrends*, November 7, 2016, mobitrends.co.ke/huawei-safaricom-phones/.
[270] Otavio Veras, "Smart Cities in Africa: Nairobi and Cape Town," *How We Made It in Africa*, April 10, 2017, www.howwemadeitinafrica.com/smart-cities-africa-nairobi-cape-town/58209/.
[271] Ibid.
[272] François de Soyres, Mohamed Abdel Jelil, Caroline Cerruti, and Leah Kiwara, "What Kenya's Mobile Money Success Could Mean for the Arab World," World Bank, October 3, 2018, www.worldbank.org/en/news/feature/2018/10/03/what-kenya-s-mobile-money-success-could-mean-for-the-arab-world.
[273] "Kenya Safaricom Successfully Migrates M-PESA to Huawei G2 Platform," *INFORM*, April 2015, inform.tmforum.org/news/2015/04/vodafone-mpesa-huawei.
[274] Ivy Nyayieka, "M-Pesa to Send Cash Direct to China's WeChat Users," *Business Daily*, November 29, 2018, www.buisnessdailyafrica.com/corporate/companies/MPesa-to-send-cash-direct-to-China/4003102-4874858-de9450/index.html.
[275] Nicole Jao, "Briefing: Alibaba to Offer M-Pesa as Payment Option on AliExpress," *Technode*, March 13, 2019, https://technode.com/2019/03/13/briefing-alibaba-to-offer-m-pesa-as-payment-option-on-aliexpress/.

ranch had been a campaign promise of President Kenyatta, but until the funding for this Huawei-led development was secured, little progress had been made. While the city is planned to include a National Cloud Data Center, Smart ICT Network, Public Safe City and Smart Traffic Solution, and Government Cloud and Enterprise Service, this loan is the first sign of progress on any such system.[276]

Huawei's smart city project in Nairobi is far more concrete in terms of targeted use and goals than the planned Konza Technology City. Kenya's capital Nairobi has long had a high crime rate,[277] a lack of security that made it a natural market for Chinese surveillance technology. In 2014, Kenya Safaricom signed an agreement with the Kenyan government to build a surveillance network in Nairobi.[278] Huawei conducted the actual construction of this project, which installed 116 LTE base stations, 1,800 cameras, 200 traffic surveillance systems, and 2 data centers.[279] They also built an Emergency Command Center in Nairobi for video monitoring and voice-based first responder dispatching, face and license plate recognition capabilities, and call center interoperability.[280] In a video on Huawei's website, a narrator says that in Nairobi, "Big Brother monitors their goings-on from miles away." As the senior superintendent of the Nairobi police force said, "Anybody who does anything is being watched."[281] Although Huawei claims its Nairobi surveillance system led to a 46 percent drop in the crime rate since going into operation in 2015, local media has questioned the system's effectiveness.[282]

Huawei is not the only Chinese technology company to offer surveillance technology to Kenya. Chinese video surveillance technology manufacturer Hikvision advertises how its "HikCentral" cloud-based video management system has been used in stores across Nairobi.[283] Dahua Technology Co. Ltd., another large surveillance technology producer, makes more than $10 million USD a year in Kenya supplying surveillance equipment for public spaces.[284]

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[276] Nakifai Tobor, "Kenya Secures $173 Million from Huawei for Data Center," *iAfrikan*, April 30, 2019, www.iafrikan.com/2019/04/30/kenya-has-secured-666-million-from/.

[277] Samuel L. Aronson, "Crime and Development in Kenya: Emerging Trends and the Transnational Implications of Political, Economic, and Social Instability," *Inquiries Journal* (2010): 1-2; James Reinl, "Tourists in Kenya Brave 'Nairobbery'," *Al Jazeera*, June 15, 2013, www.aljazeera.com/indepth/features/2013/06/201361513473477049 8.html.

[278] Kenya CitizenTV, "Safaricom Signs Security Surveillance Project," YouTube, November 24, 2014, www.youtube.com/watch?v=PQkmGW7tLDA.

[279] "Video Surveillance as the Foundation of 'Safe City' in Kenya," Huawei, Huawei.com/us/industry-insights/digital-transformation/video/video-survellance-as-the-foundation-of-safe-city-in-kenya/.

[280] Huawei, "Kenyan Safe City Can Now Sleep Better," December 24, 2015, https://archive.li/pBsxf.

[281] "[Safe City-Kenya] (平安城市·肯尼亚)," Huawei, April 10, 2018, e.huawei.com/cn/videos/cn/2018/201804101023#.

[282] "Video Surveillance as the Foundation of 'Safe City' in Kenya," Huawei, Huawei.com/us/industry-insights/digital-transformation/video/video-survellance-as-the-foundation-of-safe-city-in-kenya/; NTV Kenya, "Nairobi City Security Cameras Have Failed," YouTube, January 24, 2018, www.youtube.com/watch?v=y_28CphPDf0.

[283] "Nairobi Supermarket Chain Food Plus Gets Fresh Surveillance and Top-Choice Centralized Security," Hikvision, September 4, 2018, www.hikvision.com/europe/Press/Success-Stories/Retail/Nairobi-Supermarket-Chain-Food-Plus-Gets-Fresh-Surveillance-and-Top-Choice-Centralized-Security.

[284] "[Relying on Location, Zhejiang in Kenya] (依靠本土化，浙商在肯尼亚做得风生水起)," *Hangzhou.com.cn 杭州网*, December 8, 2018, http://hznews.hangzhou.com.cn/jingji/content/2018-12/08/content_7111079.htm.

President Kenyatta's Kenya Vision 2030 plan calls for an expansion of the national urban area surveillance system to Mombasa, Nakuru, and Kisumu.[285] Despite this plan, continued investment in larger systems like the Nairobi surveillance systems, or even more ambitious projects like the Konza Technology City, are likely to be hobbled by the limits of Kenya's budget.

Case Study: Investment and Innovation in Germany

Germany is both a vital development partner and customer of Chinese smart cities products. Though Germany has not signed on to the BRI, it is the most important of China's trading partners in Europe and a vital end node for the project's overland trade routes. In addition, it has been an important recipient of Chinese investment.[286]

Since 2011, many major German cities have pushed toward developing smart cities in pursuit of national-level and EU objectives,[287] with as much as $23.6 billion USD available for funding smart cities projects in Germany between 2014 and 2019.[288] German municipal governments have forged direct partnerships with Chinese tech companies and both countries' governments have encouraged cooperation on smart cities development efforts.[289] In 2013, German Chancellor Angela Merkel and Chinese Premier Li Keqiang established the Sino-German Urbanization Partnership in order to guide future city growth in both countries, and it has since been a route for cooperation.[290] In early 2019, leaders from both countries met to reiterate bilateral cooperation efforts.[291]

China primarily provides ICT infrastructure and municipal smart cities solutions to Germany, as well as some installations of surveillance products (see Table 12), but Germany is an exception among the developed nations studied for this chapter in that its local governments have paired with Chinese companies to develop integrated smart city platforms. The most significant smart cities projects identified in Germany involve Huawei smart cities solutions and technologies. In June 2018 and February 2019, Huawei signed agreements with the German cities of Duisburg and Gelsenkirchen outlining cooperation in smart cities construction.[292] In announcements about both

[285] "Urban Area Camera Surveillance (Pilot)," accessed 9 November 2019, http://vision2030.go.ke/project/urban-area-camera-surveillance-pilot/.

[286] "Investing in Germany – Success for Chinese Companies," Rodl & Partner, https://www.roedl.com/services/interdisciplinary-services/investing-in-germany/china; Janne Suokas, "China Runs 11,000 'Silk Road' Trains to Europe," *Global Times 环球日报*, October 29, 2018, https://gbtimes.com/china-runs-11000-silk-road-trains-to-europe.

[287] European Commission, "Commission Launches Innovation Partnership for Smart Cities and Communities," European Commission Press Release Database, July 10, 2012, http://europa.eu/rapid/press-release_IP-12-760_en.htm?locale=en.

[288] International Trade Administration, "Germany-Smart Cities," modified October 26, 2018, https://www.export.gov/article?id=Germany-Smart-Cities; European Commission, "Commission Launches Innovation Partnership for Smart Cities and Communities," European Commission Press Release Database, July 10, 2012, http://europa.eu/rapid/press-release_IP-12-760_en.htm?locale=en.

[289] "Xi Makes 3-point Proposal on China-Germany Ties in Meeting with Merkel," Xinhua, March 27, 2019, http://www.xinhuanet.com/english/2019-03/27/c_137925507.htm.

[290] "Sino-German Dialogue for Sustainable Cities," Sino-German Urbansation Partnership, July 5, 2019, https://www.sustainable-urbanisation.org/en/about#intro.

[291] "Xi Makes 3-point Proposal on China-Germany Ties in Meeting with Merkel," Xinhua, March 27, 2019, http://www.xinhuanet.com/english/2019-03/27/c_137925507.htm.

[292] "[Huawei Establishes First 'Comprehensive' Smart City Project in Germany] (华为在德国建设欧洲首个"全面"智慧城市项目)," *Shenzhen Economic Daily 深圳商报*, September 4, 2018,

agreements, Huawei sources specify that the company planned to provide ICT services to implement smart cities solutions including both data and command centers.[293] In the state of Hessen, ZTE has been awarded contracts to implement its "Smart Street 2.0" system—a collection of sensors and wide area networking equipment that collects data and provides information about available parking spots and street congestion. This system also will reportedly include garbage cans that inform municipal waste collectors when they are full and streetlights that adjust their output according to ambient conditions.[294]

Table 12: Chinese Smart City Projects Identified in Germany

Company	Technology Category	Location	Projects and Product
Huawei[295]	Big Data Network Infrastructure Municipal Services	Duisburg	Data Centers, 5G Infrastructure
		Gelsenkirchen	Smart Cars, E-Government, Surveillance, Traffic Control, Smart Parking
	Municipal Services	Hamburg	Smart Waste Management
ZTE[296]	Municipal Services Integrated Platform	Rüsselsheim am Main, Kelsterbach, and Raunheim	Smart Streetlamps, Smart Waste Management, Smart parking,

http://www.sznews.com/tech/content/2018-09/04/content_20088350.htm; "Huawei and Gelsenkirchen Sign MoU for Smart City Cooperation at MWC2019," Huawei, February 28, 2019, https://www.huawei.com/en/press-events/news/2019/2/huawei-gelsenkirchen-smart-city-cooperation-mou; "Huawei and DU-IT Help Duisburg Become a Smart City," Huawei, June 11, 2018, https://www.huawei.com/en/press-events/news/2018/6/Huawei-DU-IT-Duisburg-SmartCity.

[293] "[Huawei Establishes First 'Comprehensive' Smart City Project in Germany] (华为在德国建设欧洲首个'全面'智慧城市项目)," *Shenzhen Economic Daily 深圳商报*, September 4, 2018, http://www.sznews.com/tech/content/2018-09/04/content_20088350.htm; "Huawei and Gelsenkirchen Sign MoU for Smart City Cooperation at MWC2019," Huawei, February 28, 2019, https://www.huawei.com/en/press-events/news/2019/2/huawei-gelsenkirchen-smart-city-cooperation-mou; "Huawei and DU-IT Help Duisburg Become a Smart City," Huawei, June 11, 2018, https://www.huawei.com/en/press-events/news/2018/6/Huawei-DU-IT-Duisburg-SmartCity.

[294] ZTE, "[Contract Extension for Seville Football Club-ZTE Storms European Market] (续签塞维利亚足球俱乐部中兴通讯猛攻欧洲市场)," https://www.zte.com.cn/china/about/press-center/news/20180600001/201807140803/201703hl/34; Liu Yang 刘杨, "NetCologne: German Users Increase Network Infrastructure (NetCologne: 为德国用户提供最好的网络设施)," *ZTE Technologies Newsletter 中兴通讯技术(简讯),* https://www.zte.com.cn/china/about/magazine/zte-technologies/2017/6/cn_1337/464368; Dimitris Economou, "ZTE Cooperates with Hessen State to Create 3 Smart Cities in Germany," *Gizmochina*, March 21, 2017, https://www.gizmochina.com/2017/03/21/zte-cooperates-hessen-state-create-3-smart-cities-germany/; Anja Schmoll-Trautmann, "CeBIT: ZTE Presents Smart Street 2.0 Solution," *ZDNet*, March 20, 2017, https://www.zdnet.de/88290297/cebit-zte-praesentiert-smart-street-2-0-loesung/.

[295] Tanwen Dawn-Hiscox, "CeBIT 2018: Huawei, DU-IT Launch 'Smart City' Cloud Service in Duisburg, Germany," Data Center Dynamics, June 12, 2018, https://www.datacenterdynamics.com/news/cebit-2018-huawei-du-it-launch-smart-city-cloud-service-in-duisburg-germany/; "Smart City with AI," Huawei, https://e.huawei.com/en/material/enterprise/newict/ai/627bbbd6325a4bbf95f0657ad255bce0; "Smart City Development Creates More Livable Gelsenkirchen Manfred vom Sondern City of Gelsenkirchen," Huawei, https://e.huawei.com/en/material/event/44861d182e88455bb83f7fee60104d8d; "Telco in The City: In Hamburg, Smart Parking is A Network Concern," *Leonard*, March 8, 2018, https://leonard.vinci.com/en/telco-city-hamburg-smart-parking-network-concern/.

[296] "[Contract Extension for Seville Football Club-ZTE Storms European Market] (续签塞维利亚足球俱乐部 中兴通讯猛攻欧洲市场)," ZTE, https://www.zte.com.cn/china/about/press-center/news/20180600001/201807140803/201703hl/34; Liu Yang 刘杨, "[NetCologne: German Users Increase

			Wide Area Network, Operations Center
		Bonn	Smart Streetlamps
	Network Infrastructure	Cologne and Dusseldorf	Network Technology
Hikvision[297]	Surveillance	Cologne	Digital Video Recording
		Frankfurt	IP Cameras, Smart Parking System
		Nuremberg	Integrated Video Management System
CASIC[298]	Big Data	Frankfurt	Cloud Infrastructure
Gosuncn[299]	Network Infrastructure	[not specified]	RFID; 4G OBD Terminal
TelChina[300]	Municipal Services	[not specified]	Smart Lampposts

Huawei has also made steps to establish research centers focused on smart cities-related technologies in these German cities. In the case of Gelsenkirchen, Huawei planned to establish a research center to develop new products and applications with local partner companies.[301] Another Huawei-established lab there will develop smart municipal service technologies such as smart lighting, park management systems, and intelligent waste disposal systems.[302] Since 2016, Huawei

Network Infrastructure] (NetCologne: 为德国用户提供最好的网络设施)," *ZTE Technologies Newsletter 中兴通讯技术(简讯),* https://www.zte.com.cn/china/about/magazine/zte-technologies/2017/6/cn_1337/464368; Dimitris Economou, "ZTE Cooperates with Hessen State to Create 3 Smart Cities in Germany," *Gizmochina*, March 21, 2017, https://www.gizmochina.com/2017/03/21/zte-cooperates-hessen-state-create-3-smart-cities-germany/; Anja Schmoll-Trautmann, "CeBIT: ZTE presents Smart Street 2.0 solution," *ZDNet*, March 20, 2017, https://www.zdnet.de/88290297/cebit-zte-praesentiert-smart-street-2-0-loesung/; Goodarz Mahbobi, "Bonn: Reinventing Partnerships in The City of Beethoven," TMForum, July 2017, https://smartcityinfocus.tmforum.org/wp-content/uploads/2017/07/YinchuanSpecialReportSmartCities.pdf.

[297] "Hikvision Recorder Transports Cologne Based Museum into HD Future," Hikvision, May 22, 2017, https://www.hikvision.com/europe/News--Events/Success-Stories/Education/306386953590921; Hikvision, "Hikvision Delivers Streamlined Parking in Germany," *Asmag.com*, June 5, 2019, https://www.asmag.com/print_article.aspx?id=28407; "When German Corporations Demand Quality, It Turns to Hikvision," Hikvision, August 21, 2013, https://www.hikvision.com/europe/News--Events/Success-Stories/Retail/305529044800943; "Hikvision Overcomes Weather and Obstacles to Secure Frankfurt's Light-Rail Stations," Hikvision, September 15, 2011, https://www.hikvision.com/europe/Press/Success-Stories/Transportation/305529078524164; "Hikvision on Track in Nuremberg," Hikvision, May 5, 2011, https://www.hikvision.com/europe/News--Events/Success-Stories/Transportation/305529077069520.

[298] "[Basic Status] (基本情况)," CASICloud-Tech Co. Ltd. (航天云网(德国)有限责任公司), http://www.casicloud.cn/subsidiaries/germany.html.

[299] "[2018 International Rail and Traffic Expo, Gosun Releases Automotive Electronic Recognition Fusion Solution] (2018 国际道路交通展，高新兴将发布汽车电子标识融合解决方案)," Gosuncn Technology Group Co. Ltd. (高新兴科技集团股份有限公司), August 14, 2018, http://www.gosuncn.com/About/news_100000244519912.html.

[300] TelChina 泰华智慧, "[TelChina Wins First Place in the '2018 Huawei Developer Competition'] (泰华智慧喜获'2018 华为开发者大赛'一等奖)," *ZHJN.org 中国智慧节能网*, October 30, 2018, http://www.zhjn.org/show.asp?id=2969; "[TelChina Collaborates with Huawei, Accelerates Development Pace in Overseas Market] (泰华智慧携手华为，加快开拓海外市场步伐)," *TelChina 泰华智慧*, June 25, 2018, http://www.telchina.com.cn/article-7-745.html.

[301] "Huawei and Gelsenkirchen Sign MoU for Smart City Cooperation at MWC2019," Huawei, February 28, 2019, https://www.huawei.com/en/press-events/news/2019/2/huawei-gelsenkirchen-smart-city-cooperation-mou; "Gelsenkirchen: A Small, Smart City with Big Plans," Huawei, accessed November 12, 2019, https://e.huawei.com/kz/case-studies/global/2017/201709071445; "Huawei Joint Innovation Center," Smartmycity.com, September 20, 2018, https://smartmycity.com/projects/huawei-joint-innovation-center-6ntgn.

[302] City of Gelsenkirchen, "Gelsenkirchen: Digital Pilot Lab," Kommune21.de, March 11, 2019, https://www.kommune21.de/meldung_31060_Digitales+Versuchslabor.html.

has also established research labs in Munich and Frankfurt focused on smart manufacturing and information security.[303] In Munich, Huawei also agreed to set up a joint lab with a German startup developing smart streetlamps.[304] These labs are used in part as testbeds for new technologies and to build relationships with these kinds of tech firms. They are also in part a showcase to build public interest in smart cities technologies and acceptance of or support for Huawei's role in developing them.[305]

Local German governments' embrace of smart cities solutions from Huawei and ZTE illuminates a series of security concerns. News reports discussing Huawei's work in Duisburg make no mention of Huawei access to or control of German government data, though it can be assumed the Chinese company is legally required to comply with European Union privacy and data protection laws.

Case Study: Infrastructure and Security Cameras in the United Kingdom

The United Kingdom has been considered a leader in developing smart cities-related standards[306] and engaging domestic innovation in this field.[307] While China plays a smaller role in trade with the UK than it does in the developing country case studies,[308] and the UK is not a member of the BRI, British firms have engaged with Chinese companies in smart cities collaboration and joint development both at home and abroad. Chinese and UK governments have interacted through co-hosted forums, conferences, and workshops on smart city technologies.[309] These relationships between UK and Chinese entities appear to be focused on expanding trade opportunities in China for UK companies to supply technology as well as share knowledge and expertise. For example, a China-UK agreement made as part of China Smart Cities International Expo in August 2018 sought to provide business contacts and collaboration opportunities between companies in both

[303] Douglas Busvine, "Exclusive: China's Huawei Opens up to German Scrutiny ahead of 5G Auctions," Reuters, October 23, 2018, https://www.reuters.com/article/us-germany-telecoms-huawei-exclusive/exclusive-chinas-huawei-opens-up-to-german-scrutiny-ahead-of-5g-auctions-idUSKCN1MX1VB; "Huawei to Create New OpenLab in Munich," Huawei, August 11, 2018, https://huawei.eu/press-release/huawei-create-new-openlab-munich; "Huawei Strengthens OpenLab Program to Foster Industry Ecosystem in Europe," Huawei, November 8, 2018, https://www.huawei.com/en/press-events/news/2018/11/openlab-program-foster-industry-ecosystem-europe.

[304] "Huawei and Eluminocity Sign 'Smart City' Agreement," *BuisnessCoud.co.uk,* November 9, 2018, https://www.businesscloud.co.uk/news/huawei-and-eluminocity-sign-smart-city-agreement.

[305] "Gelsenkirchen and Huawei Sign Agreement for Smart City Cooperation," *Digital Cities Challenge*, March 6, 2019, https://www.digitallytransformyourregion.eu/gelsenkirchen-and-huawei-sign-agreement-smart-city-cooperation.

[306] "UK Offers to Build Smart Future Cities Together with China at China Smart Cities International Expo," Gov.UK, August 21, 2018, https://www.gov.uk/government/news/uk-offers-to-build-smart-future-cities-together-with-china-at-china-smart-cities-international-expo.

[307] Eric Woods, Roberto Rodriguez Labastida, Ryan Citron, Tiffany Chow, and Paige Leuschner, "UK Smart Cities Index 2017: Assessment of Strategy and Execution for the UK's Leading Smart Cities," ITU, October 23, 2017, https://www.itu.int/en/ITU-T/ssc/resources/Documents/Huawei_2nd_Smart_Cities_Index_2017_FINAL.pdf.

[308] While the UK-China trade relationship has become more important in recent decades, in 2018, China was sixth on the list of destinations for UK exports and the fourth largest source of UK imports. "Statistics on UK trade with China," House of Commons Library, November 5, 2019, https://researchbriefings.parliament.uk/ResearchBriefing/Summary/CBP-7379.

[309] "[China-US Workshop on Smart Cities, Jointly Discussing Establishing Smart Cities] (中英智慧城市研讨会 共议智慧城市建设)," *China Youth Network 中国青年网*, July 18, 2019, http://www.chinanews.com/business/2019/07-18/8898870.shtml.

countries.[310] Numerous British companies and governments have established partnerships with Chinese companies to collaborate on smart cities-related research,[311] like the partnership established in 2011 between British telecommunications provider BT and ZTE to work on telecommunications research and "develop international standards" for globally compatible systems.[312] The only Chinese company partnership with a UK local government that could be identified was Huawei's agreement in July 2017 to collaborate with the city of Milton Keynes to develop smart cities technologies.[313]

For their parts, Chinese technology companies have set up several research labs and centers in the United Kingdom to facilitate partnerships with local companies and universities. Huawei established an Open Lab and research labs focused on smart cities-enabling fields such as big data and distributed data management and processing in Newbury, London, and Edinburgh in 2014, 2016, and 2017,[314] and ZTE established an R&D and Innovation Centre for network testing and development in London in 2011.[315] Similarly, Huawei set up a research lab focused on NB-IoT at Vodafone's headquarters in Newbury in 2016 to allow for a network testing environment.[316] Although according to statements from British telecommunications providers, these relationships have not necessarily resulted in increased Chinese smart cities technology exports in the United Kingdom;[317] it would instead be a likely route for facilitating technology transfer and a way to gain local public support for Chinese technology products. Huawei has even started acquiring companies in pursuit of better positioning in the UK market—in 2014, the company acquired the UK-based startup Neul that specializes in smart city applications for IoT technology.[318]

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[310] "UK Offers to Build Smart Future Cities Together with China at China Smart Cities International Expo," Gov.UK, August 21, 2018, https://www.gov.uk/government/news/uk-offers-to-build-smart-future-cities-together-with-china-at-china-smart-cities-international-expo.

[311] "Chinese Smart Cities MOU Signed with UK Tech Company Following UKTI Trade Mission," Bikal.co.uk, http://www.bikal.co.uk/chinese-smart-cities-2015.html; Jerman Cheung, "Arup Signed Two Memoranda of Understanding (MoUs) with British Research Establishment (BRE) and Smart City Development Alliance (SCDA) to Promote The Development of Sustainable And Smart Cities in China," *Arup.com*, April 6, 2018, https://www.arup.com/news-and-events/arup-signs-mous-with-uk-and-chinese-partners-to-develop-sustainable-and-smart-cities.

[312] "BT, ZTE Announce Research Partnership," ZTE, June 2, 2011, https://www.zte.com.cn/global/about/press-clipping/353801.

[313] "Huawei Signs MOU with Milton Keynes Council to Further Smart City Innovation," Huawei, July 20. 2017, https://www.huawei.com/uk/press-events/news/uk/2017/huawei-signs-mou-with-milton-keynes-council-to-further-smart-city-innovation.

[314] "Huawei Launches Global OpenLab Program to Create An Open Ecosystem," Huawei, March 20, 2017, https://www.huawei.com/en/press-events/news/2017/3/Huawei-Launches-Global-OpenLab-Program; "Huawei And The University of Edinburgh Announce Opening of Joint Lab for Distributed Data Management and Processing," Huawei, June 13, 2017, https://www.huawei.com/uk/press-events/news/uk/2017/huawei-and-the-university-of-edinburgh-announce-opening-of-joint-lab; "'Big Data' Lab to Open in UK," *Laboratory Talk,* January 27, 2014, http://laboratorytalk.com/article/406351/big-data-lab-to-open.

[315] "ZTE Opens Innovation Centre in London Docklands," ZTE, August 22, 2011, https://www.zte.com.cn/global/about/press-clipping/353827.

[316] Scott Bicheno, "Huawei Opens NB-IoT Lab At Vodafone HQ," Telecoms.com, April 26, 2016, http://telecoms.com/472084/huawei-opens-nb-iot-lab-at-vodafone-hq/.

[317] "China's ZTE 'Poses Risk to UK Security,'" BBC, April 16, 2019, https://www.bbc.co.uk/news/technology-43784990.

[318] Paul Bischoff, "Huawei Wants to Build Smarter Cities with $25 Million Acquisition of UK-Based Startup," *Tech in Asia*, September 23, 2014, https://www.techinasia.com/huawei-build-smarter-cities-25-million-acquisition-ukbased-startup.

While it has been considered a leader in developing smart cities standards, the United Kingdom's existing data networks are not as advanced or widespread as those in other parts of Europe, which will be key to facilitating smart cities development.[319] Analysts found evidence of two types of exported Chinese smart cities technology in the United Kingdom: security cameras and ICT infrastructure (see Table 13). In contrast with the developing nations surveyed in this report, the United Kingdom appears to lack any unified smart cities or security platforms from Chinese technology providers. Instead, there is only evidence of localized security systems. In addition to these exports, Chinese technology companies have partnered with local telecommunications providers and technology suppliers to establish research centers to engage in local technology exchange. A list of the specific smart city projects conducted by Chinese technology companies in the United Kingdom that could be identified is provided in the table below.

Table 13: Chinese Smart City Projects in the United Kingdom

Company	Technology Category	Location	Projects and Products
Hikvision[320]	Surveillance	Bath, Dorset, London, Glasgow, Manchester, Nottingham, Isle of Wright	Public Space Surveillance Systems
Dahua[321]	Surveillance	[Unspecified]	Public Space Surveillance Systems

[319] Barney Cotton, "Why Are UK Cities Finding it So Hard to Become Smart?" *Business Leader*, June 21, 2019, https://www.businessleader.co.uk/why-are-uk-cities-finding-it-so-hard-to-become-smart/69011/; Rupert Jones, "UK Slips to 35th in Global Table of Broadband Speeds," *The Guardian*, July 10, 2018, https://www.theguardian.com/technology/2018/jul/10/uk-slips-to-35th-in-global-table-of-broadband-speeds.

[320] "Enhancing the Security at Southgate Shopping Centre with Hikvision," Hikvision, February 21, 2017, https://www.hikvision.com/europe/Press/Success-Stories/Retail/305529052117452;"Hikvision's IP PTZ Cameras Secure The Tank Museum," Hikvision, November 9, 2016, https://www.hikvision.com/europe/News--Events/Success-Stories/Education/306386953371910; "Hikvision Secures Burger King in United Kingdom," Hikvision, October 1, 2008, https://www.hikvision.com/europe/News--Events/Success-Stories/Retail/305529039124388; "For Sail: Lifeline and Hikvision Provide State-of-The-Art Wireless Video Surveillance System for Cowes Yacht Haven," Hikvision, November 28, 2018, https://www.hikvision.com/europe/Press/Success-Stories/Transportation/For-sail-Lifeline-and-Hikvision-provide-state-of-the-art-wireless-video-Surveillance-system-for-Cowes-Yacht—Haven; "HD Greenery: Hikvision Provides Video Surveillance Upgrade for London's Kew Gardens," Hikvision, October 22, 2018, https://www.hikvision.com/europe/Press/Success-Stories/City-Surveillance/Kew-Gardens-ITS-Hikvision-case-study; "Hikvision Helps London Borough Build Extensive CCTV Solution," Hikvision, December 11, 2013, https://www.hikvision.com/europe/News--Events/Success-Stories/City-Surveillance/305528877699609; "Glass Half Full: Maxtag and Hikvision Upgrade Security across the Fuller's estate," Hikvision, September 14, 2018, https://www.hikvision.com/europe/Press/Success-Stories/Retail/Glass-Half-Full-Maxtag-and-Hikvision-Upgrade-Security-across-the-Fullers-estate; "Hikvision Secures London Largest Shopping Park," Hikvision, July 3, 2017, https://www.hikvision.com/europe/Press/Success-Stories/Retail/305529052296615; "Hikvision Darkfighter Cameras Revolutionize Salford's Nighttime Surveillance," Hikvision, November 30, 2015, https://www.hikvision.com/europe/News--Events/Success-Stories/City-Surveillance/305528879030813; "Hikvision Cameras Push Environmental Surveillance to the Limit with Fully Mobile CCTV Solution," Hikvision, May 26, 2016, https://www.hikvision.com/europe/Press/Success-Stories/City-Surveillance/Hikvision-Cameras-Push-Environmental-Surveillance-to-the-Limit-with-Fully-Mobile-CCTV-Solution; "An Eye on the Birds: Agri-CCTV Delivers Unique Hikvision Wi-Fi Surveillance System to Poultry Farm," Hikvision, October 19, 2017, https://www.hikvision.com/europe/Press/Success-Stories/Industrial/Commercial/305529001937292.

[321] Dahua, "[Zhejiang Dahua Technology Co. Ltd. 2018 Annual Report] (浙江大华技术股份有限公司二〇一八年年度报告)," March 2019, https://www.dahuatech.com/upload/2019/03/19/15529633366852n5jhk.pdf.

TelChina[322]	Municipal Services	[Unspecified]	Smart Lighting
Huawei[323]	Network Infrastructure	Newcastle	Broadband network
Kedacom[324]	Surveillance	[Unspecified]	Public Space Surveillance Systems
DRORE[325]	Municipal Services	[Unspecified]	[Unspecified]

On the ICT infrastructure side, announcements from both Huawei and ZTE clearly state the companies' intentions to invest heavily in smart cities technologies in the United Kingdom.[326] Huawei has had a presence in the United Kingdom supplying mobile networks since opening an office there in 2001, and ZTE has recently emerged as a competitor supplying ICT infrastructure.[327] While less attention has been dedicated to reporting on the presence of Chinese surveillance cameras in the United Kingdom, Chinese-exported surveillance cameras and monitoring systems supplied by Hikvision, Dahua, and Kedacom are easily found. Compared to the rest of Europe, the United Kingdom has proportionally large quantity of CCTV cameras installed for public safety.[328] According to a 2017 report on smart cities in the United Kingdom commissioned by Huawei, many UK cities already have cameras and surveillance systems for public security and traffic management purposes.[329] Although several cases of security system sales were found across the United Kingdom, these sites lacked the unified operation platforms present in systems installed by Chinese companies in some other countries.

The United Kingdom's position as a focus for investment and innovation for China is similar to that of the United States. Like the United States, UK officials have recently voiced concerns about the security risks of allowing Chinese companies such as Huawei and ZTE to construct crucial

[322] "[TelChina Wins First Prize in '2018 Huawei Developer Contest'] (泰华智慧喜获'2018 华为开发者大赛'一等奖)," *Zhjn.org 中国智慧节能网*, October 30, 2018, http://www.zhjn.org/show.asp?id=2969.
[323] "Huawei Smart City Brochure," Huawei, https://e.huawei.com/en/material/industry/smartcity/fa01438ad7df46419a37edafaba1a788.
[324] "KEDACOM, Newcomer to Security 50, Expands Its Global Footprint," *Asmag.com*, December 20, 2017, https://www.asmag.com/showpost/24302.aspx.
[325] "[Classic Case] (经典案例)," Drore, http://www.drore.com/case; "Our Clients," Drore, https://en.drore.com/our-clients/.
[326] Kat Hall, "Chinese Rivals: ZTE to Take on Huawei... in the UK," *The Register,* September 9, 2016, https://www.theregister.co.uk/2016/09/09/zte_to_take_on_huawei_in_the_uk/; Joao Lima, "'There's No End to Smart Cities', Huawei Exec Says As World Governments Bet on Technology to Improve Security, Education and Healthcare," *Computer Business Review*, March 17, 2016, https://www.cbronline.com/internet-of-things/theres-no-end-to-smart-cities-huawei-exec-says-as-world-governments-bet-on-technology-to-improve-security-education-and-healthcare-4842303/.
[327] Andy Logan, "The Economic Impact of Huawei in the UK," *Oxford Economics*, https://www.oxfordeconomics.com/recent-releases/51856cd0-46d6-409c-bcab-218875f6b510; "UK Partners Celebrate 18 Years of Success of Working with Huawei," Huawei, May 14, 2019, https://www.huawei.com/uk/press-events/news/uk/2019/uk-partners-celebrate-18-years-of-success-of-working-with-huawei.
[328] Alice Hodgson, "Surveillance in The Smart City: How AI, IoT And Video Monitoring Can Make Cities Safer," https://www.intel.co.uk/content/www/uk/en/it-managers/smart-city-surveillance-technology-ai-iot.html; Eric Woods, Roberto Rodriguez Labastida, Ryan Citron, Tiffany Chow, and Paige Leuschner [Huawei and Navigant Consulting Inc.], "UK Smart Cities Index 2017: Assessment of Strategy and Execution for the UK's Leading Smart Cities," ITU, October 23, 2017, https://www.itu.int/en/ITU-T/ssc/resources/Documents/Huawei_2nd_Smart_Cities_Index_2017_FINAL.pdf.
[329] Eric Woods, Roberto Rodriguez Labastida, Ryan Citron, Tiffany Chow, and Paige Leuschner, "UK Smart Cities Index 2017: Assessment of Strategy and Execution for the UK's Leading Smart Cities," ITU, October 23, 2017, https://www.itu.int/en/ITU-T/ssc/resources/Documents/Huawei_2nd_Smart_Cities_Index_2017_FINAL.pdf.

broadband network and 5G infrastructure. Citing security concerns, the British government blocked ZTE 5G equipment in April 2018.[330] In late 2018, telecommunications provider BT reported it was removing Huawei components from its 4G network as part of existing plans to standardize its system.[331] In response to these concerns, Huawei set up the Huawei Cyber Security Evaluation Centre (HCSEC) to assuage concerns about its 5G network,[332] but it is likely that the establishment of this center comes with the same risk as the numerous other research-focused centers Huawei has established.

Future Plans and Trajectories

From a broader strategic standpoint, China's leaders are unlikely to abandon the accelerated export of smart city technologies and infrastructure to foreign countries. While detailed future plans to increase Chinese exports of smart city equipment are not available in open source literature, official sources indicate that China's aggressive export posture for smart cities technologies will likely remain a keystone feature of China's foreign policy. Recently-inked agreements like the 2017 "BRI Digital Economy International Cooperation Initiative" ("一带一路" 数字经济国际合作倡议) purportedly lay the groundwork for increased cooperation in the information technology industry between China and foreign countries, for which China's exports of smart cities technologies will undoubtedly play an important role.[333] A September 2019 report from the state-run newspaper *Economic Daily* confirmed that smart cities development remains an integral means of fostering cooperation between China and foreign nations engaged in the information technology component of the BRI, also known as the Digital Silk Road (数字丝路).[334] Judging by these documents and the inclusion of the BRI into the CCP's constitution,[335] the full strategy, policy, and commercial machinery of the Chinese regime is hard at work increasing Chinese exports of smart cities technologies abroad. It is difficult to imagine anything short of an abrupt policy reversal at the highest levels of Chinese governance that is likely to dramatically change the trajectory of this approach.

In some countries, Chinese companies will continue to supply smart cities technology and infrastructure, likely with continued high-level diplomatic or policy support from the Chinese government organs and financial assistance from state-run Chinese financing organizations. Many of the future prospects for expansion of Chinese exports are evident from the case studies described above, in which several countries like Ecuador and the United Kingdom express enthusiasm for more smart cities projects that would likely include Chinese participation.

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[330] "China's ZTE Deemed A 'National Security Risk' to UK," *The Guardian*, April 17, 2018, https://www.theguardian.com/technology/2018/apr/17/chinas-zte-a-national-security-risk-to-uk-warns-watchdog.
[331] Alex Hern, "BT Removing Huawei Equipment from Parts of 4G Network," *The Guardian,* December 6, 2018, https://www.theguardian.com/technology/2018/dec/05/bt-removing-huawei-equipment-from-parts-of-4g-network.
[332] Jack Stubbs, "Exclusive: Britain Says Huawei 'Shortcomings' Expose New Telecom Networks Risks," Reuters, July 18, 2019, https://www.reuters.com/article/us-huawei-security-britain-exclusive/exclusive-britain-says-huawei-shortcomings-expose-new-telecom-networks-risks-idUSKBN1K92BX.
[333] "[BRI Digital Economy International Cooperation Initiative Announced] (《"一带一路" 数字经济国际合作倡议》发布,)" *Network Broadcast 网络传播,* May 11, 2018, http://www.cac.gov.cn/2018-05/11/c_1122775756.htm.
[334] Gu Yang 顾阳, "["Digital Silk Road" Construction Will Become Engine for New Global Development][("数字丝路"建设将成全球发展新引擎)," *Economic Daily 经济日报,* September 9, 2019, http://www.gov.cn/xinwen/2019-09/09/content_5428411.htm.
[335] Brenda Goh and John Rutwich, "Pressure On as Xi's 'Belt and Road' Enshrined in Chinese Party Charter," October 24, 2017, https://www.reuters.com/article/us-china-congress-silkroad/pressure-on-as-xis-belt-and-road-enshrined-in-chinese-party-charter-idUSKBN1CT1IW.

On the other hand, a long-term strategy of exporting smart city infrastructure using heavy subsidies may prove fiscally unsustainable for China's government in the long run. Several signs point to deceleration in financial support for BRI initiatives in some development areas: analysis indicates that lending from Chinese policy banks—for all intents and purposes arms of the Chinese government—has decreased in aggregate from 2015 through 2018.[336] For their part, prominent Chinese intellectuals have objected to the government's profligacy abroad, claiming that the money used to help finance economic development in foreign countries could be better used on development in China itself.[337]

Implications for the United States

From a commercial and economic standpoint, China's emphasis on promoting the development of smart cities projects abroad presents competition and collaboration opportunities for U.S. technology firms. According to one forecast, the global smart cities market is projected to grow 18.9 percent from $71.3 billion USD in 2018 to reach $237.6 billion USD by 2025.[338] The opportunity this growth presents has prompted major technology providers to approach emerging target cities in Southeast Asia, Africa, and South America interested in procuring smart cities solutions. In the course of providing infrastructure for smart cities, Chinese technology companies have partnered with U.S. companies to develop and implement smart cities-enabling technology solutions. For example, Huawei lists numerous international firms with significant U.S. presence as part of its "Smart City Ecosystem," including Accenture, Tyco, Hexagon Software, and AgentVI.[339] Computing solutions provider Inspur partners with a number of prominent U.S. information technology companies including IBM, HP, Oracle, Seagate, Intel, and Microsoft, and has partnered with Cisco to conduct smart cities projects in China.[340] These technology partnerships entail a range of activities including ensuring technical compatibility, research collaboration, and joint hardware installation.

The prevalence of Chinese hardware, software, and infrastructure used for developing smart cities in countries abroad has the potential to affect U.S. technology companies' position in those same markets. For example, U.S. companies are already part of the smart cities landscape in Malaysia,

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[336] Matt Schrader, "Domestic Criticism May Signal Shrunken Belt and Road Ambitions," *China Brief*, August 10, 2018, https://jamestown.org/program/domestic-criticism-may-signal-china-scaling-back-its-bri-ambitions/.

[337] Xi Zhangrun 许章润, "我们当下的恐惧与期待 [Our Fears and Wishes]," Unirule Institute of Economics, July 24, 2018, http://unirule.cloud/index.php?c=article&id=4625.

[338] This figure is roughly in line with the global market research estimates cited in Chapter 5 and could conceivably contain moderate estimates of the size of the Chinese market. Other estimates place the value of the Chinese market far beyond these figures, suggesting that there may be divergence in the scope of technologies or industries included in the calculations. Many of these estimates come from industry consultants and market research firms with proprietary or undisclosed methodologies. Please see Chapter 1 for more details on the size of the Chinese market. "Smart Cities Market Analysis Report by Application (Governance, Buildings, Utilities, Transportation, Healthcare, Environmental Solution), by Region, and Segment Forecasts, 2019 - 2025," *Grand View Research*, May 2019, https://www.grandviewresearch.com/industry-analysis/smart-cities-market.

[339] Matshelane Mambolo, "ICT Collaboration Adds Layer of Safety to Nairobi, Mombasa," *ITWebAfrica*, October 14, 2016, www.itwebafrica.com/security/515-kenya/236945-ict-collaboration-adds-layer-of-safety-to-nairobi-mombasa.

[340] "Software Outsourcing Service," Inspur Group Co., Ltd, http://www.inspur.com/inspur/2226018/index.html; Inspur Group Co., Ltd., "Jinan Innovation Zone, Inspur and Cisco Signs Memorandum of Strategic Cooperation," PR Newswire, December 4, 2017, https://www.prnewswire.com/news-releases/jinan-innovation-zone-inspur-and-cisco-signs-memorandum-of-strategic-cooperation-300565849.html.

and its governments already utilize products for smart city applications from Microsoft,[341] Oracle,[342] and Hewlett Packard.[343] China's push to develop smart cities for Malaysia may push out these U.S. companies from the market, as a result of more competitive pricing and loan arrangements. At the same time, since the current environment of smart city applications is complex and requires the integration of sensors, inputs, and databases, the growing global development of smart cities may simultaneous create opportunities for U.S. firms to offer innovative products and services to create reliable smart cities.

National Security Implications

China's prolific export of smart cities technologies also has national security implications. Technology companies worldwide are frequently reluctant to share the details of data sharing and transfer arrangements publicly, and Chinese smart cities exporters are no different. Many technology companies subscribe to the theory that "data is the new oil,"[344] and Chinese technology firms are just as likely as their Western counterparts to want to exploit as much of this resource as possible. The data that Chinese technology firms collect will not only give them a competitive advantage in the development of big data platforms and AI, but it may also be available to Chinese intelligence services.[345] This has led to the fear that smart cities equipment installed abroad will be the eyes and ears of the Chinese Ministry of State Security.[346] Moreover, there is a risk that Chinese-built smart city technology could permit cyberattacks affecting U.S. allies or U.S. forces abroad.[347] In most cases studied, the full extent of any privacy or security risk remains unclear, but even with conservative assumptions, the growth of Chinese smart cities exports presents a serious economic and security challenge to the United States.

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[341] Sugriiva Paramasivam, "Going Beyond A Smart City: Malaysia's Selangor Launches #Smartstate 2025 with Azure," Microsoft.com, July 25, 2018, https://news.microsoft.com/en-my/2018/07/25/going-beyond-a-smart-city-malaysias-selangor-launches-smartstate-2025-with-azure/.

[342] Edwin Yapp, "Oracle Revenue Falls, But Malaysia Bucks the Trend," *Digital News Asia*, July 31, 2015, https://www.digitalnewsasia.com/business/oracle-revenue-falls-but-malaysia-bucks-the-trend. "Malaysia's MIMOS Partners with Oracle to Improve Transparency via Blockchain," *Asia Blockchain Review,* July 1, 2019, https://www.asiablockchainreview.com/malaysias-mimos-partners-with-oracle-to-improve-transparency-via-blockchain/.

[343] "IRDA: Smart City Framework A Big Step to Realise Smart Nation Vision," *Malay Mail*, September 23, 2019, https://www.malaymail.com/news/malaysia/2019/09/23/irda-smart-city-framework-a-big-step-to-realise-smart-nation-vision/1793389.

[344] "The World's Most Valuable Resource Is No Longer Oil, But Data," *The Economist*, May 6, 2017, https://www.economist.com/leaders/2017/05/06/the-worlds-most-valuable-resource-is-no-longer-oil-but-data.

[345] "[National Cybersecurity Law of the People's Republic of China] (中华人民共和国国家安全法)," National People's Congress of the People's Republic of China, http://www.npc.gov.cn/npc/xinwen/2016-11/07/content_2001605.html; Liza Lin and Josh Chin, "China's Tech Giants Have a Second Job: Helping Beijing Spy on Its People," *Wall Street Journal*, November 30, 2017, https://www.wsj.com/articles/chinas-tech-giants-have-a-second-job-helping-the-government-see-everything-1512056284.

[346] Joel Gehrke, "'It Improves Targeting': Americans under Threat from Chinese Facial Recognition Systems, Rubio Warns," *Washington Examiner*, August 27, 2019, https://www.washingtonexaminer.com/policy/defense-national-security/chinas-overseas-smart-city-surveillance-empire-could-trap-americans-lawmakers-warn.

[347] Anthony Bergin and Paul Barnes, "Are Smart Cities Leaving Us Vulnerable to Supervillains?" Australian Strategic Policy Institute, September 12, 2018, https://www.aspi.org.au/opinion/are-smart-cities-leaving-us-vulnerable-supervillains.

V | Smart Cities and U.S.-China Relations

Key Findings:

- The United States government has adopted a bottom-up approach to smart city development that stands in contrast to China's top-down model, taking a "convening" rather than a leading role and encouraging localized implementation with a policy focus on security and privacy as "first order design principles."
- The United States has tied its promotion of smart cities abroad to larger policy initiatives under the Indo-Pacific strategy that emphasize a values-led system as an alternative to authoritarian development models (namely, China's BRI).
- Challenges in capturing and categorizing data make comparisons of U.S. and Chinese smart cities technologies difficult, but evidence suggests that Chinese hardware is broadly on par with U.S. products, while Chinese software lags behind.
- What makes U.S. smart cities policies lasting and sustainable in the long run—the bottom-up approach that leverages local skills and advantages—also makes these communities vulnerable to compromised technologies in city infrastructure and systems, Chinese or otherwise, as the focus has historically been more on local priorities and needs than a unified, national approach to privacy and security.
- While the U.S. government has taken some steps to secure ICT systems and supply chains, Chinese smart cities products are still in use across the United States, despite known vulnerabilities and suspected potential for compromise through PRC legal mandates requiring Chinese firms to share information with their government.

As outlined in this report, the PRC has marshalled significant resources toward the stated goal of becoming the leading global smart city technology power. This leads to the question of where it stands in comparison with the United States, home to many of the companies that pioneered these technologies. This chapter explores the relative strengths of the United States and China in smart cities development, platforms, and applications in three sections. The first provides a brief overview of the context for U.S. smart cities development in terms of domestic and international policy initiatives; the second compares Chinese smart city technologies to their U.S. counterparts; and the third analyzes smart cities security and the penetration of Chinese smart cities technologies into U.S. critical infrastructure and describes the potential risks from this exposure. The chapter concludes with a discussion of the implications of these developments for the United States now and in the future.

U.S. Smart Cities: A Big-Picture, Bottom-Up Approach

The imperatives driving smart cities initiatives globally—namely, the need for sustainable urban development coupled with the emergence of new technologies for city administration—are also present in the United States. U.S. politicians and professional associations have identified a clear need for infrastructure maintenance and improvement with opportunities for smart cities growth.[348]

[348] "Hearing: The Cost of Doing Nothing: Why Investing in Our Nation's Infrastructure Cannot Wait," House Committee on Transportation and Infrastructure, February 7, 2019, https://transportation.house.gov/committee-activity/hearings/the-cost-of-doing-nothing-why-investing-in-our-nations-infrastructure-cannot-wait; American Society of Civil Engineers, "2017 Infrastructure Report Card," 2017, https://www.infrastructurereportcard.org/wp-

On a policy level, Washington has consistently emphasized a bottom-up approach to smart city development, stressing the importance of local solutions for unique local needs.[349] Thus, rather than pressing a singular approach to smart cities development, the U.S. government works in its convening capacity to connect the different nodes within the system—be it through inter-regional forums and organizations, data- and information-sharing to reduce redundancies, or large national-level meetings.[350] Both government and private actors tend to paint in broad strokes, highlighting overarching smart cities goals and corresponding ICT categories and focusing on what smart cities can accomplish rather than what defines a smart city. As a result, there is ambiguity in the use of the term "smart cities" in the United States.[351]

Federal policy support for smart cities did not gain significant momentum until 2015, when the Obama administration released its overarching "Smart Cities" Initiative, with an initial $160 million aimed at fostering greater interconnectivity and coordination in smart cities development. The Initiative was lauded as the first of its kind for connecting city initiatives with federal support[352] and its launch reflected the U.S. government assessment that greater federal support could help local communities tackle shared challenges while addressing broader goals, such as spurring domestic job creation and economic growth and expanding export opportunities for U.S. companies.[353]

As the first administration to push smart cities development, the Obama White House described smart cities as "communities that are building an infrastructure to continuously improve the collection, aggregation, and use of data to improve the life of their residents—by harnessing the growing data revolution, low-cost sensors, and research collaborations, and doing so securely to

content/uploads/2019/02/Full-2017-Report-Card-FINAL.pdf; Steve Hamilton and Ximon Zhu, "Funding and Financing Smart Cities," Deloitte Center for Government Insights, 2017, https://www2.deloitte.com/content/dam/Deloitte/us/Documents/public-sector/us-ps-funding-and-financing-smart-cities.pdf.

[349] Diane Rinaldo, "Keynote Address, 2019 GCTC," (speech, Washington, DC, July 11, 2019).

[350] Ben Miller, "Obama Places $160 Million Bet on Smart Cities, Internet of Things," Government Technology, September 16, 2015, https://www.govtech.com/fs/Obama-Places-160-Million-Bet-on-Smart-Cities-Internet-of-Things.html.

[351] A 2015 Congressional Research Service report highlighted the lack of an "established consensus definition or set of criteria for characterizing what a smart city is," a finding that has not changed substantially in the years since. In Eric A. Fisher, "The Internet of Things: Frequently Asked Questions," Congressional Research Service, October 13, 2015, https://fas.org/sgp/crs/misc/R44227.pdf.

[352] Executive Office of the President: President's Council of Advisors on Science and Technology, "Report to The President: Technology and the Future of Cities," The White House, February 2016, https://www.whitehouse.gov/sites/whitehouse.gov/files/images/Blog/PCAST%20Cities%20Report%20_%20FINAL.pdf; Katherine Peinhardt, "An Act of Faith in Cities: White House Launches 'Smart Cities' Initiative," The City Fix, September 16, 2015, https://thecityfix.com/blog/an-act-of-faith-cities-white-house-launches-smart-cities-initiative-katherine-peinhardt/; Ben Miller, "Obama Places $160 Million Bet on Smart Cities, Internet of Things," Government Technology, September 16, 2015, https://www.govtech.com/fs/Obama-Places-160-Million-Bet-on-Smart-Cities-Internet-of-Things.html.

[353] National Science and Technology Council, "Smart Cities and Communities, Federal Strategic Plan: Exploring Innovation Together," January 2017, https://www.nitrd.gov/drafts/scc_strategicplan_draft.pdf; "Commerce Releases New Guide to Help U.S. Companies Identify Commercial Smart Cities Opportunities," International Trade Administration, July 14, 2016, https://www.usaseanconnect.gov/pdfs/WhiteHouseU.S.-ASEANConnectFactSheetNew.pdf.

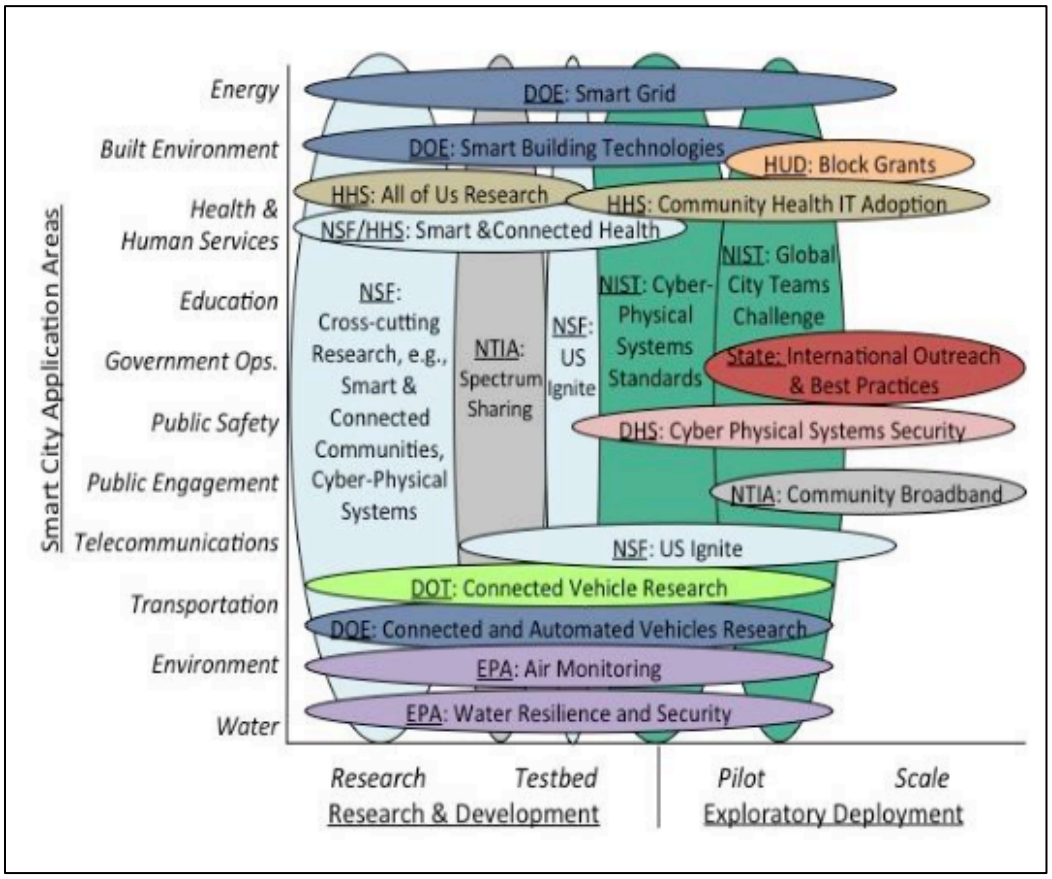
protect safety and privacy."[354] This emphasis on cybersecurity and privacy as "first order design principles" is a hallmark of U.S. government discussions of smart cities.[355]

Central to the "Smart Cities" Initiative are U.S. government agency-led efforts to bolster innovation, support new programs, and cultivate relationships among stakeholders, funded through National Science Foundation (NSF) research grants and investments from Executive-level departments targeting "national priorities" carried out at the local level.[356] NSF funding is designated for research institutions and universities working on smart cities technologies, particularly for application in their local environs, such as the NSF's $3 million grant to the University of Chicago for internet sensors in its namesake city.[357] Federal agency funding comes in forms like the Department of Commerce's Regional Innovation Strategies program, which aims to cultivate economic resiliency through regional capacity building.[358]

A U.S. federal government graphic depicting various agencies' roles in the smart cities landscape is presented below, with the vertical ovals indicating programs that span more than one application area and the horizontal ovals representing those that cover multiple technology readiness levels.[359]

[354] "FACT SHEET: Administration Announces New 'Smart Cities' Initiative to Help Communities Tackle Local Challenges and Improve City Services," The White House, Office of the Press Secretary, September 14, 2015, https://obamawhitehouse.archives.gov/the-press-office/2015/09/14/fact-sheet-administration-announces-new-smart-cities-initiative-help.
[355] "Smart Cities," Department of Homeland Security, July 2017, https://www.dhs.gov/science-and-technology/smart-cities; Alex Murtha, "DHS, NIST to Jointly Sponsor Global City Teams Challenge for 'Smart City' Solutions in 2018," *Homeland Preparedness News*, August 29, 2017, https://homelandprepnews.com/stories/23937-dhs-nist-jointly-sponsor-global-city-teams-challenge-smart-city-solutions-2018/; Chris Greer, "Welcome Remarks, 2019 GCTC," (speech, Washington, DC, July 11, 2019).
[356] "FACT SHEET: Administration Announces New 'Smart Cities' Initiative to Help Communities Tackle Local Challenges and Improve City Services," The White House, Office of the Press Secretary, September 14, 2015, https://obamawhitehouse.archives.gov/the-press-office/2015/09/14/fact-sheet-administration-announces-new-smart-cities-initiative-help.
[357] Marguerite Reardon, "Obama Pledges $160M to Develop 'Smart Cities' Apps," *CNET*, September 14, 2015, https://www.cnet.com/news/obama-pledges-160m-to-develop-smart-cities-apps/.
[358] "FACT SHEET: Administration Announces New 'Smart Cities' Initiative to Help Communities Tackle Local Challenges and Improve City Services," The White House, Office of the Press Secretary, September 14, 2015, https://obamawhitehouse.archives.gov/the-press-office/2015/09/14/fact-sheet-administration-announces-new-smart-cities-initiative-help.
[359] National Science and Technology Council, "Smart Cities and Communities, Federal Strategic Plan: Exploring Innovation Together," The Networking and Information Technology Research and Development Program, January 2017, https://www.nitrd.gov/drafts/scc_strategicplan_draft.pdf.

Figure 7: Federal Government Agencies in Smart Cities



Source: Networking and Information Technology Research and Development Program (NITRD).[360]

The Trump administration's 2018 "Connecting and Securing Communities through Digital Technologies: A Guide for Federal Agencies" shows that the White House view of the U.S. government role in smart cities continues to emphasize "empowering local governments and their stakeholders," arguing that "smart city/community projects are inherently undertaken at the state and local levels" and pushing for federal agencies to "align efforts with state, regional, and local needs."[361] While the Trump administration has not explicitly referenced the "Smart Cities" Initiative, it has built on the groundwork the previous administration laid. A sample of key U.S. government policies and programs, both domestic and abroad, is presented in Table 14.

[360] National Science and Technology Council, "Smart Cities and Communities, Federal Strategic Plan: Exploring Innovation Together," The Networking and Information Technology Research and Development Program, January 2017, https://www.nitrd.gov/drafts/scc_strategicplan_draft.pdf.
[361] "Connecting and Securing Communities: A Guide for Federal Agencies Supporting Research, Development, Demonstration, and Deployment of Technology for Smart Cities and Communities," Executive Office of the President.

Table 14: Key Federal Government Smart Cities Efforts

Agency	Smart City Programs and Highlights
Department of Transportation	The 2015 "Smart City Challenge" offered $40 million to a mid-sized city that could demonstrate how to use intelligent transportation systems (ITS) as a means of improving travel efficiency and reducing environmental impact from travel.[362]
Department of Commerce	A Bureau of Industry and Security program provides tools and seminars for U.S. companies seeking to export smart cities products to ensure compliance with U.S. export controls.[363]
	The 2016 *Smart Cities, Regions, and Communities: Export Opportunities (Guide)* is "designed to assist U.S. companies in competing for and winning business opportunities in the emerging Smart Cities space" and aims to "increase U.S. export opportunities and support American job creation by providing insights into new global opportunities and challenges."[364]
	A late 2016 MoU signed with Singapore's Ministry of Trade focuses on promoting smart cities solutions in the region under the auspices of U.S.-ASEAN Connect.[365]
	The U.S. International Trade Administration has sponsored smart cities technology-specific trade missions to countries such as China, Spain, and India.[366]
	In 2016, NIST's GCTC partnered with foreign governments, including Japan and South Korea.[367]
Department of Energy	Supported a 2010 program by the California Public Utilities Commission to adopt smart metering systems.[368]
White House	In 2015, the White House Office of Science and Technology Policy designated Charlotte, North Carolina as the model for its "Envision America" smart cities program, hosting a workshop on cross-sector collaboration.[369]

[362] "Smart City Challenge," U.S. Department of Transportation, July 29, 2017 https://www.transportation.gov/smartcity.
[363] "Smart Cities, Regions, and Communities: Export Opportunities," International Trade Administration, Summer 2016, https://www.trade.gov/markets/smartcities.pdf.
[364] "Commerce Releases New Guide to Help U.S. Companies Identify Commercial Smart Cities Opportunities," International Trade Administration, July 14, 2016, https://www.trade.gov/press/press-releases/2016/commerce-releases-new-guide-to-help-us-companies-identify-commercial-smart-cities-071416.asp.
[365] "FACT SHEET: U.S.-ASEAN Connect," The White House: Office of the Press Secretary, September 8, 2016, https://www.usaseanconnect.gov/pdfs/WhiteHouseU.S.-ASEANConnectFactSheetNew.pdf.
[366] Sokwoo Rhee, Martin Burns, and Cuong Nguyen, "Global City Teams Challenge 2016," National Institute of Standards and Technology, June 2017, https://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.1900-01.pdf; "Global City Teams Challenge 2016: Kick-off Workshop-Draft Summary Report," National Institute of Standards and Technology, December 2015, http://www.goventures.biz/files/GCTC_2016_Nov.2015_Kick-off_Workshop_Draft_Report_1.6.2016.pdf; "Smart Cities Infrastructure Trade Mission: India," Export.gov, November 23, 2015, https://2016.export.gov/trademissions/smartcitiesindia2016/; "Smart Cities, Regions, and Communities: Export Opportunities," International Trade Administration, Summer 2016, https://www.trade.gov/markets/smartcities.pdf.
[367] Sokwoo Rhee, Martin Burns, and Cuong Nguyen, "Global City Teams Challenge 2016," National Institute of Standards and Technology, June 2017, https://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.1900-01.pdf; "Global City Teams Challenge 2016: Kick-off Workshop-Draft Summary Report," National Institute of Standards and Technology, December 2015, http://www.goventures.biz/files/GCTC_2016_Nov.2015_Kick-off_Workshop_Draft_Report_1.6.2016.pdf
[368] "Report to the Governor & the Legislature on Smart Grid Plans and Recommendations," California Public Utilities Commission, December 2010.
[369] Matt Ball, "White House Announces Envision Charlotte to Host Launch of National Envision America Initiative in January, 2016," Informed Infrastructure, September 15, 2015, https://informedinfrastructure.com/17079/white-house-announces-envision-charlotte-to-host-launch-of-national-envision-america-initiative-in-january-2016/; "White House Announces Envision Charlotte to Host First Envision America Workshop," City of Charlotte, September 14, 2015, https://charlottenc.gov/Mayor/News/Pages/White-House-announces-Envision-Charlotte-to-host-first-Envision-America-Workshop.aspx.

	In 2016, the U.S. set aside $80 million as a follow-up to the 2015 "Smart Cities" Initiative that doubled the number of participating communities. The funding targets four key issue areas: climate, transportation, public safety, and transforming city services.[370]
Department of Homeland Security	In 2018, the Department of Homeland Security established a Smart City IoT Innovation solutions lab to focus "on the integration of new and existing technologies applied to public safety needs with an emphasis on extensive validation and go-to-market support through partners."[371]

For their parts, leading U.S. companies generally highlight the interconnectivity and harmonization of technical components to increase efficiency and improve citizens' lives.[372] U.S. cities like New York and San Francisco tend to discuss specific projects undertaken as part of municipal smart city efforts (e.g., "Midtown in Motion [is] a smart city approach to traffic management" and "The launch of the new Bigbelly recycling program…[is] part of Atlanta's Smart City programming").[373] Both cities and corporate entities are consistent in their deference to the importance of privacy, with Cisco calling to "establish privacy as a fundamental human right in the digital economy" and with numerous cities spearheading legislation on smart cities data privacy.[374]

U.S. Smart Cities Initiatives Abroad and the Indo-Pacific Strategy

Federal government efforts to support U.S. companies looking to export and deploy smart cities technologies overseas have lagged behind these companies' entrance into foreign markets but evolved in tandem with U.S. smart cities policies, which have come to recognize the diplomatic value of smart cities promotion in strengthening bilateral and multilateral relationships and

[370] "FACT SHEET: Announcing Over $80 million in New Federal Investment and a Doubling of Participating Communities in the White House Smart Cities Initiative," The White House: Office of the Press Secretary, September 26, 2016, https://obamawhitehouse.archives.gov/the-press-office/2016/09/26/fact-sheet-announcing-over-80-million-new-federal-investment-and.

[371] "Smart City Internet of Things Innovation (SCITI)," DHS Science and Technology Directorate, 2018, https://www.dhs.gov/sites/default/files/publications/1001_R-Tech_Smart-City-Internet-Things-Innovation_SCITI-FactSheet-180713-508.pdf.

[372] "BM Offers Smarter City Assessment Tool to Help Cities Prepare for Challenges and Opportunities of Unprecedented Urbanization," IBM, June 24, 2009, https://www-03.ibm.com/press/us/en/pressrelease/27791.wssl; "What Is a Smart City?" Cisco, 2019, https://www.cisco.com/c/en/us/solutions/industries/smart-connected-communities/what-is-a-smart-city.html; "Smart Cities: How Rapid Advances in Technology Are Reshaping Our Economy and Society," Deloitte, November 2015, https://www2.deloitte.com/content/dam/Deloitte/tr/Documents/public-sector/deloitte-nl-ps-smart-cities-report.pdf.

[373] "Building a Smart + Equitable City," NYC Mayor's Office of Tech + Innovation, September 2015, https://www1.nyc.gov/assets/forward/documents/NYC-Smart-Equitable-City-Final.pdf; "Media Advisory: Mayor Kasim Reed to Launch New Bigbelly Recycling Program," City of Atlanta, November 27, 2017, https://www.atlantaga.gov/Home/Components/News/News/10275/632?npage=5&arch=1; "We've Got Somewhere to Be," Smart Pittsburgh, 2016, http://smartpittsburgh.org/programs; "Smart City Challenge-San Francisco: Harnessing The Future of Shared Mobility," Smart City San Francisco, 2016, http://smartcitysf.com/assets/Smart_City_Fact_Sheet.pdf.

[374] "Metro Atlanta Smart Cities Workshop Resources," Georgia Municipal Association, 2019, https://www.gacities.com/Resources/Reference-Articles/Metro-Atlanta-Smart-Cities-Workshop-Resources.aspx; Piyush Pandey, Deborah Golden, Sean Peasley, and Mahesh Kelkar, "Making Smart Cities Cybersecure," Deloitte, April 11, 2019, https://www2.deloitte.com/us/en/insights/focus/smart-city/making-smart-cities-cyber-secure.html; "Cisco Calls for Privacy to Be Considered a Fundamental Human Right," CISCO, February 7, 2019, https://newsroom.cisco.com/press-release-content?type=webcontent&articleId=1965781; Kaveh Waddell, "Cities Are Writing Privacy Policies," Axios, June 29, 2019, https://www.axios.com/cities-data-privacy-laws-fa0be8cb-234f-4237-b670-10ad042a772e.html.

increasing government transparency.[375] This is reflected in the prominence given to pursuing international collaboration in key policies and programs like the 2015 "Smart Cities" Initiative.[376]

U.S. policy has also recognized the importance of smart cities development for global economic competitiveness. The President's Council of Advisors on Science and Technology (PCAST) in a 2016 report affirmed that "[t]ransforming cities around the world…is already a race—one that the United States cannot afford to lose." The report highlighted China as one of several countries that has dispensed "considerable organization and resources to become leaders in urban innovation."[377]

The Trump administration has further embedded the promotion of U.S. smart cities technologies in its broader foreign policy. Numerous statements since Donald Trump's January 2017 inauguration have tied smart cities to the infrastructure development and value-promotion goals of the Indo-Pacific strategy. This includes the U.S.-ASEAN Smart Cities Partnership (USASCP), an inter-agency initiative announced in November 2018 and described as an "effort [that] will spur renewed American investment in the region's digital infrastructure, advancing prosperity and security in Southeast Asia."[378] USASCP aims to enhance the U.S. private sector role in the ASEAN region, strengthen subnational cybersecurity capabilities, and foster relationships between U.S. and ASEAN cities.[379] Another goal of the program is to increase market access for U.S. companies through joint efforts between the Departments of State and Commerce.[380]

In its USASCP efforts, the U.S. government emphasizes the need for "high-quality, sustainable [smart cities] infrastructure" and works with local communities to stress the importance of transparency in signing smart cities contracts with vendors, encouraging the active role of citizens in smart city decision-making—particularly in evaluating smart city projects and how data will be handled.[381] These objectives align with broader U.S. foreign policy efforts to promote shared values.

In essence, the USASCP is a piece of a broader effort to uphold and promote U.S. values as a centerpiece of the Indo-Pacific Strategy. Other corresponding initiatives that overlap with smart cities promotion include:

- The Digital Connectivity & Cybersecurity Partnership, a "multi-year, whole of government effort to promote an open, interoperable, secure, and reliable Internet" that includes the stated objective of "promot[ing] exports of U.S. ICT goods and services and

[375] "Global City Teams Challenge 2016: Kick-off Workshop-Draft Summary Report," NIST, December 2015, http://www.goventures.biz/files/GCTC_2016_Nov.2015_Kick-off_Workshop_Draft_Report_1.6.2016.pdf.
[376] "FACT SHEET: Administration Announces New 'Smart Cities' Initiative to Help Communities Tackle Local Challenges and Improve City Services," The White House, Office of the Press Secretary, September 14, 2015, https://obamawhitehouse.archives.gov/the-press-office/2015/09/14/fact-sheet-administration-announces-new-smart-cities-initiative-help.
[377] Executive Office of the President: President's Council of Advisors on Science and Technology, "Report to the President: Technology and the Future of Cities."
[378] "Ambassador Donovan's Remarks at the APCAC Business Summit," U.S. Embassy & Consulates in Indonesia, March 12, 2019, https://id.usembassy.gov/ambassador-donovans-remarks-at-the-apcac-business-summit/; "Remarks by Vice President Pence at the 6th U.S.-ASEAN Summit," The White House, November 14, 2018, https://www.whitehouse.gov/briefings-statements/remarks-vice-president-pence-6th-u-s-asean-summit/.
[379] Ibid.
[380] Dr. Elisabeth Smela (Jefferson Science Fellow, U.S. Department of State), interviewed by Jessica Drun, Washington, DC, November 2019.
[381] Ibid.

increas[ing] U.S. company market share in target markets" and "provid[ing] a credible alternative to top-down, authoritarian approaches to internet and ICT development."[382]

- Asia EDGE - Enhancing Development and Growth through Energy, an effort to "grow sustainable and secure energy markets throughout the Indo-Pacific" that calls to strengthen "national and regional power systems including through improvements to utility models and grids."[383]
- The Infrastructure Transaction and Assistance Network, with three stated core functions:
    - "Strengthening capacity-building programs to improve partner countries' project evaluation processes, regulatory and procurement environments, and project preparation capacity;
    - "Providing transaction advisory serves to support sustainable infrastructure; and
    - "Coordinating U.S. assistance support for infrastructure and catalyzing private-sector-led investment throughout the region."[384]

This whole-of-government approach to a values-led Indo-Pacific strategy with focused smart cities promotion and peripheral initiatives has the principal aim of providing alternatives to authoritarian models. Congressional legislation, such as the Better Utilization of Investments Leading to Development (BUILD) Act and the Asia Reassurance Initiative Act (ARIA),[385] supporting these efforts takes as "a key policy rationale" responding to "China's BRI and China's growing economic influence in developing countries…[and providing] an alternative to a state-directed investment model."[386]

Comparing Chinese and U.S. Smart City Development

With recognition of the Chinese government's aggressive efforts to promote smart cities development, concerns about whether or not the United States is falling behind have become more pronounced.[387] Chinese officials have been bullish about China's prospects for becoming the global smart cities leader, and as Xu Ming, a vice president at Chinese telecommunications multinational ZTE, stated in 2015, "Many countries are running their smart city pilot projects. But according to what we have observed, none of them can move on the development as systematically

[382] "The Digital Connectivity & Cybersecurity Partnership," materials from the U.S. Department of State.
[383] "Asia EDGE- Enhancing Development and Growth through Energy," materials from the U.S. Department of State.
[384] "The Infrastructure Transaction and Assistance Network (ITAN,)" materials from the U.S. Department of State
[385] FAA Reauthorization Act of 2018, Pub. L. No. 115-254, 132 Stat 3186 (2018); Asia Reassurance Initiative Act of 2018, Pub. L. No. 115-409, 132 Stat 5388 (2018); Daniel F. Runde, "America's Global Infrastructure Opportunity: Three Recommendations to the New U.S. Development Finance Corporation," CSIS, April 2019, https://www.csis.org/analysis/americas-global-infrastructure-opportunity-three-recommendations-new-us-development-finance.
[386] Shayerah Ilias Akhtar and Marian L. Lawson, "BUILD Act: Frequently Asked Questions About the New U.S. International Development Finance Corporation," Congressional Research Service, January 15, 2019, https://fas.org/sgp/crs/misc/R45461.pdf.
[387] Graham Allison, "China is Pulling Ahead of North American on Smart Cities," Axios, July 10, 2019, https://www.belfercenter.org/publication/china-pulling-ahead-north-america-smart-cities; Consumer Technology Association and United Parcel Service, "The Evolution of Smart Cities and Connected Communities," CTA Market Research Report, January 2017, https://www.slideshare.net/UPSLongitudes/the-evolution-of-smart-cities-and-connected-communities.

as China."[388] While the speed, scale, and ambition of China's smart cities development is attention-grabbing, a comparative evaluation of U.S. market power and relative technological strengths in smart city hardware and software suggests that pessimism is premature.

As smart cities platforms encompass an ecosystem of markets and interlocking technologies, many comparative studies focus on factors such as market size, government support for research and development, and availability of technical and managerial know-how rather than focusing only on the relative maturity of individual technologies.[389] Using this lens, one study concluded that China lags behind the United States in developing component technologies for smart cities, including in IoT devices that support smart city operations such as public utilities and traffic management.[390] Some industry surveys have taken another approach to assessing overall smart city development, attempting to gauge comparative progress by examining implementation in major urban centers. Still other metrics focus on the development status of key component technologies or the comparative market power of leading technology companies. The following sections briefly outline the findings of these comparative approaches.

Comparing Cities

In 2018, the ESI ThoughtLab commissioned a study comparing urban centers' progress in smart cities development. With the cooperation of smart city industry leaders like Oracle and in partnership with a variety of consultancies and academic institutions, the study graded overall smart city development by surveying government leaders, 750 business leaders, and 2,000 residents in 136 cities around the world to determine their overall advancement. Cities were rated as "beginner," "transitioning," and "leader" based on their progress in applying smart city programs to improve governance, economy, infrastructure, talent, funding, mobility, environment, public safety, public health, and payment systems.[391]

Even though the study did not include smaller Chinese cities, its findings indicate that China's most developed smart cities lag behind their U.S. counterparts in several respects but have overtaken U.S. cities in others, at least in the opinion of those surveyed. For instance, New York rated higher on mobility and environment than Beijing, but Shanghai was rated as a leader in smart crime technology maturity, while New York was rated as a beginner. Both Beijing and Shanghai's payment system benefits were rated as transitioning, while New York's was graded as beginner.[392]

In spite of the methodological pitfalls inherent in this type of qualitative study, the grades assigned to cities in the United States and China appear to reflect overall perceptions about relative Chinese advances in certain smart city applications. Experts and leaders appear to believe that the most advanced Chinese smart cities have already gained an edge in smart crime management technology

[388] He Huifeng, "China Poised for Leadership Role in Smart City Technology as Rural to Urban Migration Continues," *South China Morning Post*, November 18, 2015, https://www.scmp.com/tech/china-tech/article/1879927/china-poised-leadership-role-smart-city-technology-rural-urban.
[389] Nir Kshetri, "The Evolution of the Internet of Things Industry and Market in China: An Interplay of Institutions, Demand, and Supply," *Telecommunications Policy* 41 (November 2016): 49-67.
[390] Nir Kshetri, "The Evolution of the Internet of Things Industry and Market in China: An Interplay of Institutions, Demand, and Supply," *Telecommunications Policy* 41 (November 2016): 49-67.
[391] ESI ThoughtLab, "Smarter Cities 2025: Building a Sustainable Business and Financing Plan," ESI ThoughtLab, November 2018, https://econsultsolutions.com/wp-content/uploads/2018/11/ESI-ThoughtLab_Cities_2025_Whitepaper_FINAL.pdf.pdf.
[392] ESI ThoughtLab, "Smarter Cities Benchmark Tool," accessed November 21, 2019, https://econsultsolutions.shinyapps.io/smartercities/.

and payment technology. Some of these perceptions are not surprising, especially given the CCP's very real enthusiasm for mass surveillance technology detailed in Chapters 3 and 4 and China's rapid popular embrace of digital payment technology.

Comparing Constituent Technologies

These city rankings point to the influence of specific technologies in propelling overall smart city development levels. For this reason, examining the development stages of individual technologies and enabling infrastructure can indicate national comparative advantage both in specific smart city products and for key technologies, in smart city development overall.

A few smart cities technologies have attained widespread market penetration within China, even beyond major metropolitan areas. One such area is in smart surveillance technologies.[393] As discussed in Chapter 3, China moved to achieve widespread adoption of smart surveillance technologies and is currently a world leader in producing surveillance technologies such as facial recognition.[394] Moreover, China has achieved a dominant position in marketing those technologies abroad in countries such as Kenya and Ecuador.[395] However, many nations in target markets such as North America and Europe have more stringent data privacy protections and also harbor security concerns about products originating from the PRC,[396] so while Chinese surveillance technology firms offer a wide array of advanced products, they may be open to challenge from rival manufacturers.

China is currently a world leader in smart finance and banking. Currently, more than a billion people in China use smart payment apps such as Alipay to process day-to-day transactions, with mobile payments platforms processing more than $41 trillion annually.[397] Moreover, Chinese mobile banking firms have made progress penetrating overseas markets; Chinese mobile payment options were accepted in more than 40 countries globally as of 2018.[398] Chinese smart banking firms such as Ant Financial (蚂蚁金服), the parent company of Alipay, have also acquired or

[393] "China Smart Cities Market 2019-2023: Focus on Smart Infrastructure, Smart Transportation, & Video - Increasing Population, Need for Rapid Urbanization, and Governments' Initiatives," CISION PR Newswire, 43549, https://www.prnewswire.com/news-releases/china-smart-cities-market-2019-2023-focus-on-smart-infrastructure-smart-transportation--video---increasing-population-need-for-rapid-urbanization-and-governments-initiatives-300817584.html.

[394] Steven Feldstein, "The Global Expansion of AI Surveillance," Carnegie Endowment for International Peace, September 17, 2019, https://carnegieendowment.org/2019/09/17/global-expansion-of-ai-surveillance-pub-79847?mod=article_inline; Lei Zhang, Zizhu Zhang, Qian Xiang, and Biao Liu, "Opportunities and Challenges for Smart City Development in China," *Journal of Civil Engineering and Architecture*, December 2018, https://www.davidpublisher.org/Public/uploads/Contribute/5b31e7d716e36.pdf.

[395] Paul Mozur, Jonah M. Kessel, and Melissa Chan, "Made in China, Exported to the World: The Surveillance State," *New York Times*, April 24, 2019, https://www.nytimes.com/2019/04/24/technology/ecuador-surveillance-cameras-police-government.html.

[396] Jenny O'Brien, "Data Privacy 2019—The Lowdown," Auth0, February 7, 2019, https://auth0.com/blog/data-privacy-2019-the-lowdown/.

[397] Aaron Klein, "Is China's New Payment System the Future?" Brookings Institution, June 1, 2019, https://www.brookings.edu/wp-content/uploads/2019/06/ES_20190614_Klein_ChinaPayments_2.pdf.

[398] "WeChat Alipay Has Been Launched in Nearly 40 Countries and Regions Abroad" (微信支付宝已在境外近 40 个国家和地区落地), February 28, 2018, Xinhua, http://www.xinhuanet.com/fortune/2018-02/28/c_1122467214.htm.

This risk is compounded by the fact that the regulatory and standardization ecosystem for smart cities technologies in the United States is nascent at best. As of 2019, there is no unified set of mandatory standards outlining security protocols for the deployment of smart cities platforms in the United States. Rather, security standards for smart city products are governed by an ad hoc collection of guidelines generated by government and private entities.

Chief among these is NIST's "Framework for Improving Critical Infrastructure Cybersecurity," more commonly known as the NIST Cybersecurity Framework,[425] commissioned in 2013 by the Obama administration and finalized in 2017.[426] The Framework provides guidelines that entities ranging from municipalities to private firms can use to self-assess their security effectiveness based on risk management factors. While the Framework does not provide in-depth technical guidance, it nevertheless outlines a "common language and taxonomy" for smart city operators to assess and respond to cybersecurity challenges as they develop.[427] Additionally, NIST has sought to connect smart cities operators with industry security experts through platforms such as the Global City Teams Challenge (GCTC) and the "Internet of Things-Enabled Smart City Framework" (IES-City Framework).[428]

Federal initiatives such as the NIST Framework are supported by private entity frameworks such as MITRE ATT&CK: the former provides a set of indicators and tactics, techniques, and procedures (TTPs) that network defense analysts can use to prevent intrusions while the latter provides guidelines for the management and coordination of defense teams. Security managers also cross-apply existing industrial control systems (ICS) models.[429] Collectively, these models provide more in-depth guidance that smart cities platform operators can use to respond to specific technical challenges. The methodologies they outline work for a variety of threat models, since the same approaches used in securing a private firm or bank network also apply in defending ICS.

Nevertheless, these frameworks are "best practices" guidelines and are not universally applied or enforced within the United States.[430] The lack of a comprehensive and system-wide standardization regime has implications for U.S. national security and economic interests, particularly regarding market competition, as discussed below.

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[425] "Framework for Improving Critical Infrastructure Cybersecurity," National Institute of Standards and Technology, April 16, 2018, https://nvlpubs.nist.gov/nistpubs/CSWP/NIST.CSWP.04162018.pdf.
[426] Tara Seals, "#IMCUS: NIST Cybersecurity Framework Can Address Big Smart City Challenges," *Infosecurity Magazine,* December 6, 2016, https://www.infosecurity-magazine.com/news/imcus-nist-cybersecurity-framework/.
[427] Ibid.
[428] "A Consensus Framework for Smart City Architectures," IES-City Framework, September 30, 2018, https://s3.amazonaws.com/nist-sgcps/smartcityframework/files/ies-city_framework/IES-CityFramework_Version_1_0_20180930.pdf; "Global City Teams Challenge," National Institute of Standards and Technology, June 30, 2014, https://www.nist.gov/el/cyber-physical-systems/smart-americaglobal-cities.
[429] "Enterprise Matrix," MITRE | Attack, July 1, 2019, https://attack.mitre.org/matrices/enterprise/; "Gaining the Advantage: Applying Cyber Kill Chain Methodology to Network Defense," Lockheed Martin, 2015, https://www.lockheedmartin.com/content/dam/lockheed-martin/rms/documents/cyber/Gaining_the_Advantage_Cyber_Kill_Chain.pdf; Chris Foreman, "Cyber-Security in Industrial Control Systems," Purdue University, https://engineering.purdue.edu/VAAMI/ICS-modules.pdf; Mounir Kamal, "ICS Layered Threat Modeling," SANS Institute: Information Security Reading Room, https://www.sans.org/reading-room/whitepapers/ICS/ics-layered-threat-modeling-38770.
[430] Furthermore, none of the aforementioned frameworks specifically address the risks posed by employing technologies originating from China.

Determining Vulnerabilities in Smart Cities

While it is difficult to evaluate whether vulnerabilities in Chinese smart cities hardware pose a disproportionate threat when installed within U.S. infrastructure, numerous structural factors weigh against the safety of Chinese products, such as China's legal regime, which requires domestic companies to comply with the demands of its intelligence services. Legislation like the 2016 Cybersecurity Law and 2015 National Security Law compel Chinese companies to provide access to Chinese intelligence services, particularly the Ministry of State Security.[431] It is unclear whether or not Chinese companies operating in the United States would abide by Chinese law.

Additionally, the placement of Chinese hardware in U.S. infrastructure systems may confer military advantage to China, allowing for the inclusion of vulnerabilities that can be concealed, a topic of interest to the PLA. Chinese military writers argue that exploiting and preventing supply chain vulnerabilities is central to the global contest for information domain dominance. In a 2013 work, prominent information and network warfare theorist and PLA officer Ye Zheng covers a range of potential PLA sabotage and hardware destruction operations, including "hardware hidden mine" attacks.[432] The most recent authoritative *Science of Military Strategy*[433] from the PLA Academy of Military Sciences discusses exploiting adversary supply chains and other vulnerabilities, giving primacy to offensive operations because information networks are "easy to attack but difficult to defend." These writings make clear that PLA strategists prioritize sabotage, such as exploiting supply chain vulnerabilities, as central to China's future warfighting.

These theoretical musings align with steps China has taken in recent years to establish the capability to exploit foreign supply chain vulnerabilities. Within its national strategy of military-civilian fusion, China's universities, military and civilian science and technology research centers, and defense conglomerates conduct defensive and offensive research on advanced supply chain attacks, including "hardware trojans."

Beyond surveys of information security professionals, the primary quantitative sources available regarding hardware vulnerabilities are world databases of Common Vulnerabilities and Exposures (CVEs), which enable civilian researchers to publicly disclose discoveries of vulnerabilities in key components. Comparing the relative frequency and severity of reported CVEs for Chinese and Western products offers some insight into the relative strength of their security implementations over time and an estimate of the increased risk Chinese components embedded in Western critical infrastructure pose. However, in multiple recent cases, China is alleged to have violated standard vulnerability disclosure rules for strategic and economic advantages, rendering this data set unreliable. Information security research firm Recorded Future detected a pattern showing that the Chinese National Vulnerability Database (CNNVD) often withholds disclosure of severe vulnerabilities at the apparent behest of the Ministry of State Security (MSS) when Chinese

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[431] John Chen, Emily Walz, Brian Lafferty, Joe McReynolds, Kieran Green, Jonathan Ray, and James Mulvenon, "China's Internet of Things," Research Report prepared on behalf of the U.S.-China Economic and Security Review Commission, October 2018, https://www.uscc.gov/sites/default/files/SOSi_China%27s%20Internet%20of%20Things_Executive%20Summary.pdf.

[432] Ye Zheng [叶征], ed., *Lectures on the Science of Information Operations [信息作战学教程]* (Beijing: Academy of Military Sciences Press, 2013).

[433] Shou Xiaosong [寿晓松], ed., *Science of Military Strategy [战略学]* (Beijing: Academy of Military Sciences Press, 2013).

hackers are using them for intelligence collection.[434] When publicly confronted with this evidence, CNNVD's only response was to attempt to falsify relevant data retroactively in order to hide the trend.[435] Separately, Western media reports indicate that the U.S. and British governments are aware of current Chinese intelligence efforts aimed at negatively influencing the score of Western products in 5G equipment security testing in order to give Chinese firms a competitive advantage in the process.[436] According to these allegations, Chinese military and/or intelligence service hackers are clandestinely sharing newly discovered vulnerabilities in Western devices with testers in an attempt to have them declared "unsafe" (or at the very least, no safer than Chinese equipment) when global supply chain standards are being created.

While CNNVD data is inadequate in determining whether Chinese or Western firms offer the most secure smart cities devices, the subjective metrics noted above, such as expert surveys and examinations of China's legal code, strongly support the idea that Chinese smart cities technologies are more vulnerable on the whole than their Western counterparts. Allowing those devices into sensitive U.S. urban infrastructure therefore risks importing those vulnerabilities.

Managing Supply Chain Risk: Huawei and the United States

The assessment that Chinese smart cities platforms pose potentially heightened risks to users is bolstered by concerns about the security of Chinese products that continue to emerge, of which Huawei is a leading example. In 2019, the company faced accusations that Huawei enterprise networking products had been shipped with numerous vulnerabilities that left them ripe for unauthorized access that could compromise privacy or functionality. Technical experts noted that in a 36-hour testing period, proprietary scanning software discovered an average of 102 vulnerabilities in 1.5 million firmware files from 558 Huawei enterprise networking products, and at least a quarter of these vulnerabilities would allow an unauthorized hacker to easily gain control of the device. The testers remarked that the number of vulnerabilities was "much more than comparable Western products…these are among some of the worst devices we've ever tested."[437] In addition, in early 2019, British telecommunications multinational Vodafone Group acknowledged that it had discovered a number of vulnerabilities in Huawei equipment installed in its internet infrastructure going back years, and that these holes remained even after Huawei claimed to have patched them.[438]

Fears of security vulnerabilities have caused many U.S. government and private institutions to try to limit the number of potentially insecure products incorporated into their respective infrastructures.[439] At the federal level, these restrictions are extensively coordinated, as smart cities

[434] Priscilla Moriuchi and Bill Ladd, "China's Ministry of State Security Likely Influences National Network Vulnerability Publications," November 16, 2017, https://www.recordedfuture.com/chinese-mss-vulnerability-influence/.
[435] Priscilla Moriuchi and Bill Ladd, "China Altered Public Vulnerability Data to Conceal MSS Influence," March 9, 2018, https://www.recordedfuture.com/chinese-vulnerability-data-altered/.
[436] Anna Isaac, Christopher Williams, Hannah Boland, "China 'Rigs' 5G Test to Favour Huawei," *The Telegraph*, June 1, 2019, https://www.telegraph.co.uk/business/2019/06/01/china-rigs-5g-test-favour-huawei/.
[437] Sydney Freedberg, "Hacker Heaven: Huawei's Hidden Backdoors Found," *Breaking Defense*, July 5, 2019, https://breakingdefense.com/2019/07/hunting-huaweis-hidden-back-doors/.
[438] Daniele Lepido, "Vodafone Found Hidden Backdoors in Huawei Equipment," *Bloomberg,* April 30, 2019, https://www.bloomberg.com/news/articles/2019-04-30/vodafone-found-hidden-backdoors-in-huawei-equipment.
[439] Smart City Supercluster Panel, Smart Cities Conference (GCTC Conference, July 11, 2019, Washington, D.C.).

contractors are required to abide by mandatory security standards.[440] Moreover, in some cases, federal grant money distributed to local municipalities for smart city development appears to be contingent on the recipients' compliance with certain regulations governing supply chain management.[441] For instance, reports indicate that small wireless carriers are rethinking the use of Chinese technology in their infrastructure as a result of recent federal pressure to avoid using Huawei and ZTE equipment. As of March 2018, a proposed FCC rule would "prohibit carriers from using money from the Universal Service Fund to buy gear from companies deemed to pose national security risks," limiting access to the $8.5 billion fund that subsidizes phone, wireless, and broadband service to poor or remote communities.[442]

Efforts at the state and municipal levels to reduce supply chain risks from smart cities platforms are significantly less robust and coordinated. Although many local governments model their supply chain acquisitions strategies after the federal government, they are beholden to resource restrictions their federal counterparts do not face.[443] Anecdotal evidence suggests that many local governments and local service providers have not prioritized managing security risks from imported smart city products and have instead opted to adopt whichever platform is most economically viable (i.e., cheapest).

For instance, LHTC Broadband, a cable provider that services the small town of South Canaan, Pennsylvania, opted to use Huawei equipment given that it is "very competitively priced."[444] On the West Coast, Eastern Oregon Telecom had the same decision calculus, with its CEO Joseph Franell noting that Huawei products were 40 percent cheaper than competitors, more reliable, and that the company sells products not available from U.S. companies, going as far as successfully urging the company to export its cable modem termination systems to the United States.[445] According to a local media report, Franell is aware "of at least three other small rural telecoms in Oregon that use Huawei equipment" but did not provide details on the specific companies.[446] Further, representatives from both LHTC Broadband and Eastern Oregon Telecom were unconvinced that using Huawei products posed any immediate security risks.[447] Notably, personnel from both companies also toured Huawei facilities in China at Huawei's invitation.[448]

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[440] "Federal Smart Cities and Communities Programs Resource Guide," Networking and Information Technology Research and Development Program, July 18, 2019, https://www.nitrd.gov/apps/smartcity/.
[441] Ibid.
[442] Steve Lohr, "F.C.C. Joins Push to Limit China Telecom's Reach," *New York Times,* March 26, 2018, https://www.nytimes.com/2018/03/26/technology/fcc-huawei-security-rule.html?module=inline.
[443] "Smart Cities: A Look at Risks and Opportunities for Technology Companies," Wiley Rein LLP, February 2017, https://www.wileyrein.com/newsroom-newsletters-item-Smart-Cities-A-Look-at-Risks-and-Opportunities-for-Technology-Companies.html.
[444] Matt Picht, "This Pa. Town Is an Unlikely Front in The U.S.-China Trade War," *Newsy*, September 12, 2019, https://www.newsy.com/stories/trump-s-huawei-crackdown-could-risk-rural-broadband-access/.
[445] Jade McDowell, "Huawei Blacklist Could put a Damper on Progress for Rural Broadband," *East Oregonian*, June 8, 2019, https://www.eastoregonian.com/news/local/huawei-blacklist-could-put-a-damper-on-progress-for-rural/article_f41aa702-88b5-11e9-b957-eb170a1c3e11.html
[446] Kyle Iboshi, "Rural Oregon Caught in US fight with China and Huawei Telecommunications," KGW8, March 20, 2019, https://www.kgw.com/article/news/investigations/rural-oregon-caught-in-us-fight-with-china-and-huawei-telecommunications/283-c3942ab7-0761-4a63-9284-6d5e564ed143
[447] Matt Picht, "This Pa. Town Is An Unlikely Front in the U.S.-China Trade War"; Jade McDowell, "Huawei Blacklist Could put a Damper on Progress for Rural Broadband."
[448] Drew FitzGerald and Stu Woo, "In U.S. Brawl with Huawei, Rural Cable Firms Are an Unlikely Loser," *The Wall Street Journal*, March 27, 2018, https://www.wsj.com/articles/caught-between-two-superpowers-the-small-

A video titled "Huawei: Connecting Rural America" produced by Huawei and filmed at LHTC's headquarters has been used for marketing, while Chinese state media have referenced CEO James Kail's statements to back up Beijing's narrative that restricting Huawei and other Chinese companies runs counter to U.S. interests.[449]

Given these examples, the fear is that municipalities, lacking the quality and sophistication of large, corporate cybersecurity defenses, are becoming more vulnerable to devastating cyberattacks even as they increase their reliance on networked infrastructure.[450] Professional services firm PwC has previously determined that smart cities everywhere are "alarmingly" exposed to cyberattacks, and U.S. cities that do not have significant resources at hand to protect their smart cities systems may be especially at risk.[451] Tellingly, many U.S. telecommunications companies outside the top four that operate in more rural and less populated areas do not have chief technology officers or chief information security officers on staff to evaluate cyber vulnerabilities and ensure regular network security assessments and fixes.[452]

While Huawei has earned a lot of attention, it is not the only Chinese technology company generating security concerns. In 2017, ex-National Security Agency technical experts noted that security cameras made by the Chinese company Zhejiang Dahua Technology Co., Ltd., had a firmware vulnerability that was being actively exploited to send data to unknown IP addresses in China through rarely-used ports. When contacted by these experts, Dahua reportedly fixed the vulnerability in a firmware update, only for the same experts to discover the same vulnerability in a different part of the code.[453] Congress later prohibited federal agencies from purchasing Chinese-made video surveillance equipment in fiscal year 2019, singling out Dahua as one of the main targets of the ban.[454]

Chinese Smart City Technologies in the United States

What makes U.S. smart cities policies inherently lasting and sustainable in the long run—the bottom-up approach that leverages local skills and advantages—may also make these communities especially vulnerable as local needs trump national priorities. The risk of compromised

town-cable-guy-1522152000; Kyle Iboshi, "Rural Oregon Caught in US fight with China and Huawei Telecommunications."

[449] Huawei, "Huawei: Connecting Rural America," YouTube Video, September 2, 2019, https://www.youtube.com/watch?v=5R66Ra9XN_8; May Zhou, "Huawei ban being felt in rural US," *China Daily*, May 31, 2019, http://www.chinadaily.com.cn/a/201905/31/WS5cf14eb1a3104842260bef3c.html; "Xinhua Headlines: No threat, only good partnership – Huawei in eyes of U.S. rural telecom carrier," *Xinhua*, May 28, 2019, http://www.xinhuanet.com/english/2019-05/28/c_138096678.htm; "Xinhua Headlines: Restricting Huawei Backfires on U.S. Interests, Disrupts Global Telecom Industry," *Xinhua*, May 24, 2019, http://www.xinhuanet.com/english/2019-05/24/c_138086393.htm.

[450] David Gilbert, "U.S. Cities are Under Attack from Ransomware – and It's Going to Get Much Worse," Vice, June 17, 2019, https://www.vice.com/en_us/article/vb9p5b/us-cities-are-under-attack-from-ransomware-and-its-going-to-get-much-worse.

[451] Garry Booth, "Smart Cities Wake up to Cyber Threat," Lloyds, 2019, https://cityriskindex.lloyds.com/2019/02/05/smart-cities-wake-up-to-cyber-threat/.

[452] Rear Admiral (ret.) David Simpson (Professor of Practice, Virginia Polytechnic Institute and State University), interviewed by Jessica Drun and Jason Callahan, Vienna, VA, November 2019.

[453] Sydney Freedberg, "Hacker Heaven: Huawei's Hidden Backdoors Found," *Breaking Defense*, July 5, 2019, https://breakingdefense.com/2019/07/hunting-huaweis-hidden-back-doors/.

[454] Olivia Carville, "Banned Chinese Security Cameras are Almost Impossible to Remove," *Bloomberg*, July 10, 2019," https://www.bloomberg.com/news/articles/2019-07-10/banned-chinese-security-cameras-are-almost-impossible-to-remove.

technologies being installed in city infrastructure and systems increases as U.S. government smart cities priorities like national security and privacy are fragmented and deprioritized at the local level. Local and municipal governments and critical infrastructure providers in the United States appear to use Chinese-made products or services regularly in their implementation of smart cities, although the corpus of evidence makes it extremely difficult to ascertain the actual degree to which U.S. smart city solutions are dependent upon Chinese-made components. The extent of this reliance is likely greater in geographic and technological areas where Chinese companies have already achieved market-leading status.

Quantitative appraisals of local and municipal U.S. government reliance on Chinese-made products or infrastructure in smart cities are often unavailable or deeply unreliable at best. The highly integrated and globalized nature of the supply chain for smart cities technologies means that pinpointing the exact provenance of a given piece of hardware or software can be extremely difficult. To make matters worse for investigators, suppliers and providers of smart city equipment can be incentivized to mislead observers about the origin of their equipment,[455] especially as trade tensions with China have escalated in the last two years. Last but not least, because smart cities technologies are categorized as such based on their application rather than any intrinsic hardware or software qualities, almost no reliable data exists that could quantify U.S. reliance on Chinese smart cities technologies specifically. As a result, much of the quantitative data that could shed light on the degree of U.S. dependence on Chinese-made smart cities systems is incomplete, inaccurate, obscured, or proprietary.

Nevertheless, some quantitative information augmented by qualitative evidence may help illustrate the contours of local U.S. reliance on Chinese-made smart city products. The following sections use international trade data and anecdotal evidence to characterize the degree of U.S dependence upon Chinese-made products or infrastructure in smart cities. International trade data, grouped in the form of Harmonized Commodity Description and Coding System (HS) codes, gives a broader, macro-level understanding of approximately how reliant U.S. smart city manufacturers may be upon Chinese-made items. For its part, anecdotes from U.S. end users of smart cities equipment provide insight into areas that might be at heightened risk from Chinese-made products. Taken together, these two types of data paint a picture of a complex supply chain problem with very little accurate, complete data but very real risks to critical infrastructure.

Chinese Imports to the United States

Available data indicates significant Chinese smart city-relevant technology imports to the United States. A 2019 U.S. government report names China as the largest foreign supplier of ICT equipment to the United States, totaling $157 billion in 2018, which represented 60 percent of total U.S. ICT imports.[456] In 2017, the Observatory of Economic Complexity at the MIT Media Lab found that the bulk of U.S. imports from China are products categorized as "machines," of which

[455] A prominent recent example of this is Aventura's re-labeling of Chinese cameras bound for the U.S. military as "Made in America." See Timothy B. Lee, "Six Arrested for Selling Chinese Gear to Military as "Made in America"," *Ars Technica*, November 8, 2019, https://arstechnica.com/tech-policy/2019/11/feds-arrest-couple-for-fraudulently-selling-chinese-gear-to-us-military/.

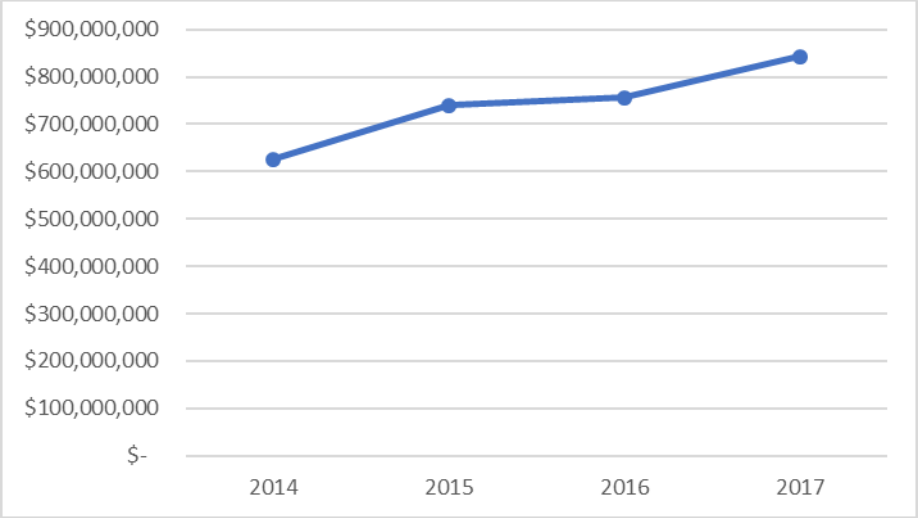
[456] Wayne M. Morrison, "U.S. China Trade Issues," Congressional Research Service, June 23, 2019, https://fas.org/sgp/crs/row/IF10030.pdf.

the majority—some 14 percent of total Chinese exports to the United States valued at $67.4 billion—is broadcasting equipment.[457] Another $3.55 billion was video recording equipment.[458]

U.S. Reliance on Chinese Imports

International trade data suggests that local and municipal governments and critical infrastructure providers are likely heavily reliant upon Chinese-made products, especially given China's strong presence in the export market for a variety of technological hardware components that are invariably used in smart cities technology applications. In one such example, shown in the figure below, Chinese exports of electricity supply or production meters, many of which will increasingly be used in smart city applications, increased from more than $626 million USD in 2014 to more than $842 million USD in 2017, suggesting that Chinese products were becoming more widely used in the United States.[459]

Figure 8: Chinese Exports of Electricity Supply / Production Meters to United States (in U.S. Dollars)



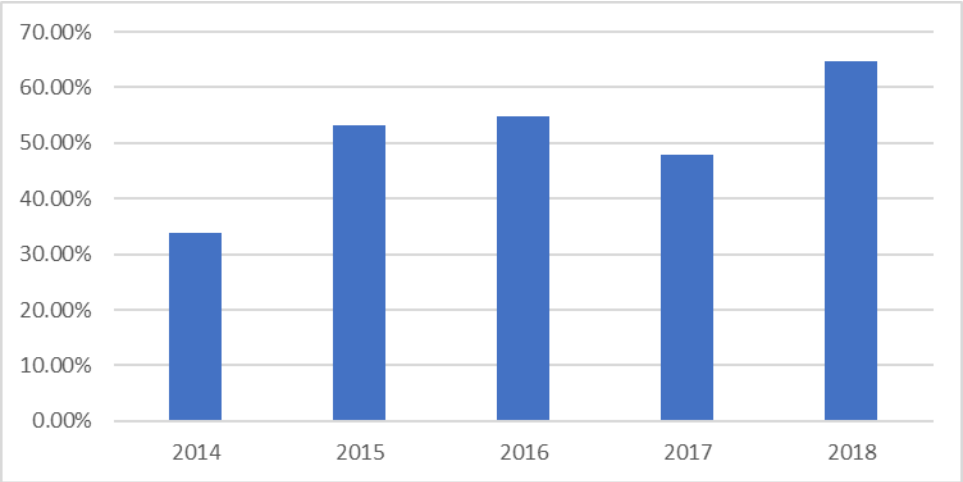
Source: Panjiva trade data.

Comparative data on China's relative strength in the export market is more illustrative. For instance, Chinese companies accounted for some 49.91 percent of total U.S. imports of telecommunications base stations (HS code 851761), a critical piece of communications infrastructure upon which smart city development relies, from December 2013 through September 2019.[460] Chinese trade data from 2014 to 2018, depicted in the figure below, shows that the percentage of telecommunications base stations exports originating from China increased from 33 percent to nearly 65 percent by U.S. dollar value in that time period.[461] Chinese dominance in the U.S. import market for telecommunications base stations significantly increases the chances that

[457] "What Does China Export to the United States? (2017)," Observatory of Economic Complexity, 2018, https://oec.world/en/visualize/tree_map/hs92/export/chn/usa/show/2017/.
[458] "What Does China Export to the United States? (2017)," Observatory of Economic Complexity, 2018, https://oec.world/en/visualize/tree_map/hs92/export/chn/usa/show/2017/.
[459] Chinese export data provided by Panjiva, a data-driven AI company specializing in global supply chain data.
[460] U.S. Census data provided by Panjiva.
[461] Chinese export data provided by Panjiva.

U.S. cities may acquire Chinese-made communications infrastructure for their smart cities applications.

Figure 9: Percentage of U.S. Imports of Base Stations Originating from China (by U.S. Dollar Value)

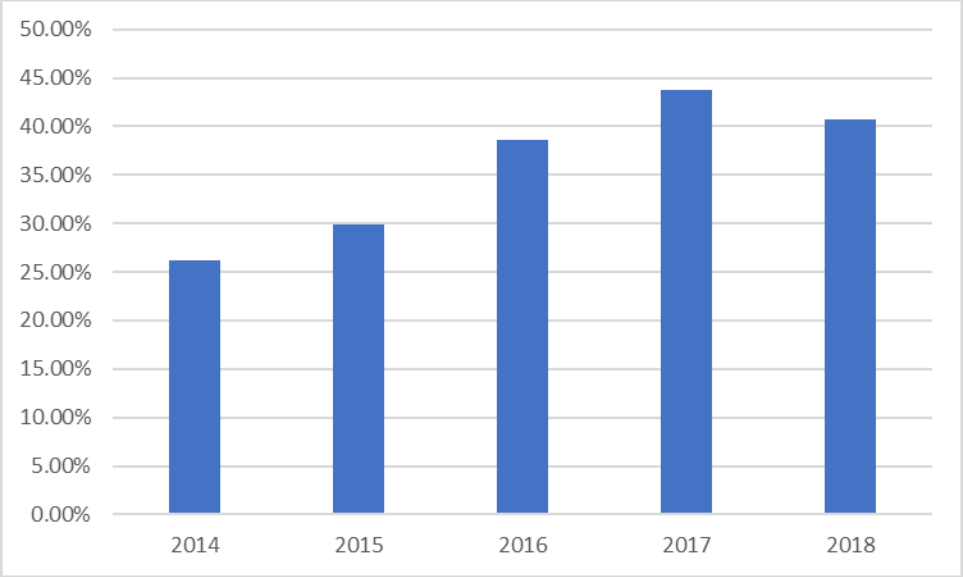


Source: Panjiva trade data.

In other areas, international trade data suggests that U.S. entities may have very little choice in incorporating Chinese-made technologies into their systems. Thanks to a complex, highly integrated global supply chain and Chinese export market dominance by U.S. dollar value, U.S. municipalities may buy equipment or technological solutions either sourced from China or built with components made in China without knowing it. For instance, many of the hardware sub-components used in smart cities technologies in the United States are made and exported by China: from December 2013 through September 2019, China accounted for an aggregated 44.21 percent of the exports to the United States by U.S. dollar value of printed circuits (HS code 853400).[462] The Chinese share of exported automatic regulating or controlling instruments and thermostats (HS code 903210), critical to making on-the-fly adjustments in infrastructure according to data inputs gathered by smart cities sensors, increased from 26.13 percent in 2014 to 40.68 percent in 2018, as indicated in the figure below.[463] These data suggest that even if U.S. municipalities are well aware of a potential information security risk in using Chinese hardware, they may still not be able to ensure supply chain integrity when purchasing smart city technologies.

[462] U.S. Census data provided by Panjiva.
[463] U.S. Census data provided by Panjiva.

Figure 10: Percentage of U.S. Imports of Automatic Regulating and Controlling Instruments Originating from China (by U.S. Dollar Value)



Source: Panjiva trade data.

Anecdotal evidence, however, presents a more mixed picture of the degree of reliance on Chinese-made products. Some local authorities are particularly reliant on comparatively inexpensive Chinese ICT products. The Rural Wireless Association, a trade group representing small wireless carriers, estimates that replacing Huawei and ZTE equipment in critical wireless infrastructure will cost these carriers some $800 million to $1 billion USD.[464] One example is the city of Opheim, Montana, where local officials and infrastructure providers argue that they will be unable to expand wireless service without using Huawei equipment. The chief executive of Nemont Telephone, the primary provider for Opheim, estimated that replacing Huawei gear would cost some $50 million USD.[465]

Other anecdotes likewise suggest that Chinese presence in U.S. smart cities applications is most prominent in market segments where Chinese products are especially dominant in the world marketplace. Hikvision, a subsidiary of state-owned defense electronics conglomerate China Electronics Technology Group Co., Ltd. (CETC), whose success in exporting surveillance equipment abroad is described in Chapter 4, has also been active in sales across the United States. The website for one of its overseas subsidiaries, California-based Hikvision USA, Inc., highlighted multiple cases where Hikvision products were being used in the United States, described below.[466]

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[464] Cecilia Kang, "Huawei Ban Threatens Wireless Service in Rural Areas," *New York Times,* May 25, 2019, https://www.nytimes.com/2019/05/25/technology/huawei-rural-wireless-service.html.
[465] Cecilia Kang, "Huawei Ban Threatens Wireless Service in Rural Areas," *New York Times,* May 25, 2019, https://www.nytimes.com/2019/05/25/technology/huawei-rural-wireless-service.html.
[466] "Success Stories," Hangzhou Hikvision Digital Technology Co., Ltd., https://us.hikvision.com/en/announcements/success-stories; Hangzhou Hikvision Digital Technology Co., Ltd., "Hikvision 2018 Annual Report," April 20, 2019, http://file.finance.sina.com.cn/211.154.219.97:9494/MRGG/CNSESZ_STOCK/2019/2019-4/2019-04-25/5252841.PDF; "Business Search," California Secretary of State, https://businesssearch.sos.ca.gov/.

- Hikvision USA, Inc. provided a mobile surveillance solution to the Utica Police Department in New York state, supplying the department with eight Hikvision cameras and a network video recorder. Hikvision's website quoted a "system engineer" at the U.S. company that installed the cameras who said, "We've been working with Hikvision for nine years and found the wide range of products appealing. Hikvision surveillance technology is great, the price points offer great value for the included features, and the complete system with brackets and mountings set Hikvision apart from the competition with a seamless, professional solution."[467]
- Hikvision USA, Inc. provided a high-end security system to Denver-based A-1 Security Systems for use at a medical marijuana grow facility in Boulder, Colorado. The security system included 95 indoor and outdoor security cameras and several network video recorders. The owner of the facility praised Hikvision for offering "a better platform that is more affordable then [sic] prior systems we used."[468]
- The Memphis Police Department has established a network of nearly 600 Hikvision cameras placed at "strategic points" around the city that feed livestreamed security footage into the department's Real Time Crime Center. The Memphis Police Department also combined its collected video footage with "unique software that provides instant information on recent criminal activity in a radius around a crime, existing crime patterns in the surrounding area, and a history of people with arrest records who may frequent the neighborhood."[469] The website did not indicate if the software was also a Hikvision product.

While these anecdotes suggest a heavy U.S. reliance on Chinese smart city products, other examples suggest a much more limited Chinese presence in selected types of smart cities systems deployed around the country. For instance, smart traffic systems in wide use across the United States do not appear to be Chinese-designed or Chinese-built. The InSync Adaptive Traffic Control System is sold as an integrated smart traffic system by Kansas-based Rhythm Engineering and deployed at more than 3,000 street intersections nationwide.[470] Other smart cities systems like smart meters also appear to be supplied by U.S. providers. Smart water meters with radio-frequency transmission capabilities in use in New York City as part of the Automated Meter Readers (AMR) program are supplied by Aclara Technologies, a U.S. company.[471] Aclara Meter Transmission Units used as part of the AMR program[472] are not only not Chinese, but are further

[467] "Hikvision Surveillance System Secures 'The Armadillo,' A Repurposed Armored Truck Used by the Utica Police Department," Hangzhou Hikvision Digital Technology Co., Ltd., March 14, 2018, https://us.hikvision.com/en/announcements/success-stories/hikvision-surveillance-system-secures-armadillo-repurposed-armored-truck-used-utica-police-department-deter-crime.
[468] "Hikvision Surveillance System Secures Marijuana Grow Facility in Boulder, Colorado," Hangzhou Hikvision Digital Technology Co., Ltd., November 3, 2017, https://us.hikvision.com/en/announcements/success-stories/hikvision-surveillance-system-secures-marijuana-grow-facility-boulder-colorado.
[469] "Memphis Hits the Right Notes with Surveillance," Hangzhou Hikvision Digital Technology Co., Ltd., January 22, 2016, https://us.hikvision.com/en/announcements/success-stories/memphis-hits-right-notes-surveillance.
[470] "Rhythm Engineering Homepage," Rhythm Engineering, accessed November 21, 2019, https://rhythmtraffic.com/.
[471] "Aclara Technologies LLC," Bloomberg, accessed November 21, 2019, https://www.bloomberg.com/profile/company/0118817D:US.
[472] City of New York Department of Environmental Protection, "List of Approved Water Meters and Related Equipment," Bureau of Customer Services Technical Services Division, October 2017, https://www1.nyc.gov/assets/dep/downloads/pdf/pay-my-bills/customer-service/list-approved-water-meters-related-equipment.pdf.

compliant with National Institute of Science and Technology (NIST) Advanced Encryption Standard 256-bit encryption standards.[473]

Even if these smart traffic and smart meter systems are assembled, sold, or installed by U.S. companies, however, this still may not guarantee that these systems do not contain Chinese sub-components that may increase the risk of technical compromise. Some of these systems likely use white-labeled Chinese sub-components, as is common practice among technology suppliers.[474] Chinese dominance in the export of smart cities sub-components, as illustrated above with macro-level international trade data, increases the chances that Chinese sub-components are integrated into ostensibly U.S.-made or -designed products.

Ultimately, the degree of Chinese presence in U.S. smart city applications likely tracks with those areas in which Chinese technologies already have significant market advantage earned through relative product quality, competitive pricing, or both. Chinese video surveillance behemoths like Hikvision and Dahua have considerable market power that makes it difficult for U.S. municipalities to turn down their wares. Even if U.S. municipalities select non-Chinese products, overall Chinese dominance in the export market for the sub-components that would likely wind up in smart cities technologies would make it difficult for U.S. localities to ensure supply chain integrity.

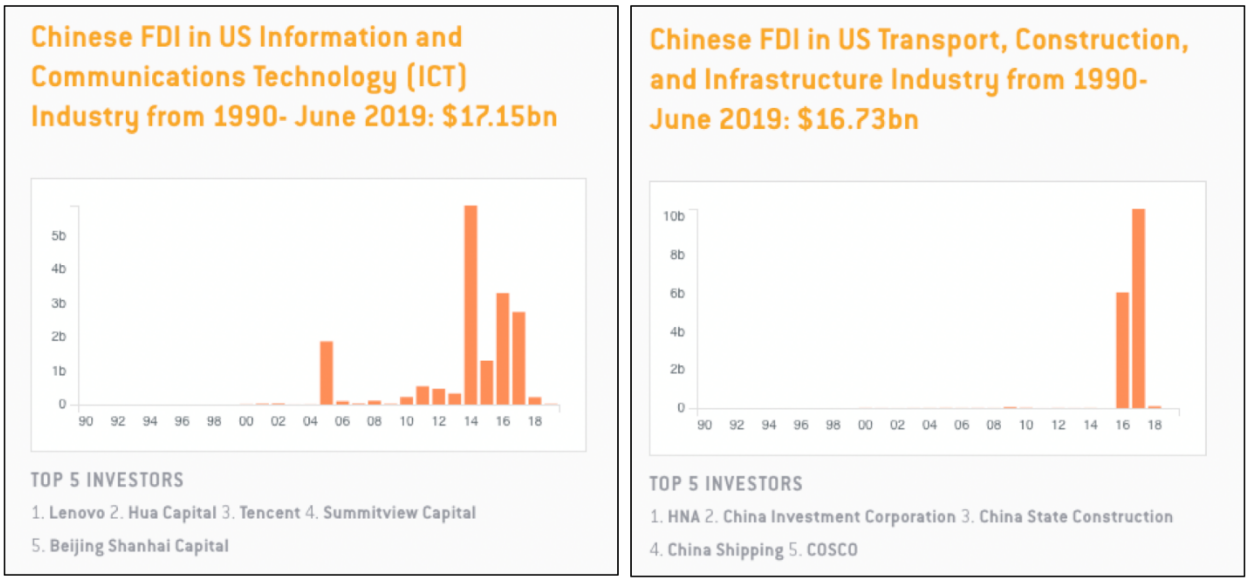
Beyond Imports: Foreign Direct Investment, Joint Ventures, and Policy Capture

An alternative risk for compromise in the U.S. smart cities market and supply chain is through Chinese foreign direct investment (FDI), which raises the possibility that Chinese companies may acquire critical technologies, access sensitive data on U.S. citizens, or be mistaken for U.S. products. National-level data provided by the Rhodium Group's "U.S.-China Investment Hub" on Chinese FDI in ICT and transport, construction, and infrastructure indicates that Chinese investment in the United States in areas relevant to smart cities has declined significantly in recent years (from $10.41 billion USD in 2017 to $100 million USD in 2018 for transport, construction, and infrastructure and from $2.73 billion USD to $217 million USD in 2018 for ICT), following a surge in the first half of the decade, particularly for ICT, as seen in Figure 11.

[473] "RF Electric Meter Transmission Unit," Aclara Technologies, August 2018, https://www.aclara.com/wp-content/uploads/2018/08/Synergize-RF-MTU.pdf

[474] The InSync smart traffic system appears to use FLIR brand cameras, although company documents do not openly acknowledge this. See "InSync Installation and Maintenance Guide," Rhythm Engineering, April 2018, https://trafficbot.rhythmtraffic.com/wp-content/uploads/InSync-Ver-1_8-SDLC-Installation-and-Maintenance-Guide-1.pdf, p. 24. Although FLIR is not a Chinese company, it too uses white-labeled cameras from Chinese companies like Dahua. See "FLIR-Branded SMB Transition to Dahua," Dahua Technology, October 29, 2018, https://us.dahuasecurity.com/2018/10/29/flir-branded-smb-transition-to-dahua/.

Figure 11: Chinese FDI in Two Smart City-Relevant Industries from 1990 to June 2019



Source: Rhodium Group.[475]

The bulk of this investment comes through mergers and acquisitions (94 percent or $16.11 billion USD of total ICT FDI and 98 percent or $16.41 billion USD of total transport, construction, and infrastructure FDI).[476] Primary Chinese investors in this field include key state-owned enterprises, such as COSCO and China Shipping, which were early investors in the United States.[477] An investigation of investments at the congressional district level provides more specific examples, including a CRRC (中国中车) bid to build subway cars for the Chicago Transit Authority and the metro transportation systems of Boston and Philadelphia.[478] In Michigan, one of China's largest aerospace and defense conglomerates, the state-owned and PLA-linked Aviation Industry Corporation of China (AVIC, 中国航空工业集团公司), acquired Nexteer, a "leader in intuitive motion control" and "automated driving technologies."[479]

Compromised or vulnerable products could also enter U.S. cities through smart cities technologies coming out of joint ventures or collaborations between U.S. and Chinese firms and municipalities.

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[475] "The U.S.-China Investment Hub: Chinese FDI in US Transport, Construction, and Infrastructure Industry from 1990-June 2019: $16.73 bn," Rhodium Group, June 2019, https://rhodiumgroup.gistapp.com/us-china-foreign-direct-investments/data.

[476] "The U.S.-China Investment Hub: Chinese FDI in US Transport, Construction, and Infrastructure Industry from 1990-June 2019: $16.73 bn," Rhodium Group, June 2019, https://rhodiumgroup.gistapp.com/us-china-foreign-direct-investments/data.

[477] "The U.S.-China Investment Hub: Chinese FDI in US Transport, Construction, and Infrastructure Industry from 1990-June 2019: $16.73 bn," Rhodium Group, June 2019, https://rhodiumgroup.gistapp.com/us-china-foreign-direct-investments/data.

[478] "New Neighbors: 2018 Update, Chinese Investment in the United States by Congressional District," National Committee on U.S.-China Relations and the Rhodium Group, April 2018, https://rhg.com/wp-content/uploads/2018/04/RHG_New-Neighbors-2018_Full-Report_9April2018.pdf.

[479] "New Neighbors: 2018 Update, Chinese Investment in the United States by Congressional District," National Committee on U.S.-China Relations and the Rhodium Group, April 2018, https://rhg.com/wp-content/uploads/2018/04/RHG_New-Neighbors-2018_Full-Report_9April2018.pdf; "About Nexteer," Nexteer, 2019, https://www.nexteer.com/about/; "About Us," Suniva, 2019, http://www.suniva.com/about-us.php.

In 2016, the U.S. company Sensity Systems Inc., whose investors include Cisco and General Electric, formed a joint venture with a company owned by the Chinese Academy of Sciences (CAS) named CAS Smart City. The *Wall Street Journal* described the goal of the joint venture as helping to "build new-wave data networks with such features as video surveillance and sensors to monitor traffic and air quality."[480] Though the initial target market focused on cities in China, products would be sold in global markets "under the Sensity platform program."[481] Sensity was purchased by Verizon that same year and while it is unclear whether or not the joint venture continued under the acquisition, the projected start date aligns with the time of purchase in the third quarter of 2016 and is unlikely to have been scrapped.[482]

Other joint ventures between Silicon Valley and China include ventures involving Silver Springs Networks Inc. (now Itron), which specializes in managing smart devices through Software-as-a-Service (SaaS) platforms, and Guangdong Rongwen Energy Science and Technology Group (广东荣文能源科技集团), which specializes in smart street lighting solutions.[483] Cisco is developing a "Cisco Smart City" project in partnership with the government of the Guangzhou Panyu district, aided by the U.S. global innovation platform Plug and Play and ten strategic partners, all of which are cloud computing-related companies surrounding applications like smart health, smart logistics, and data centers.[484] The senior vice president of Cisco Greater China says the company has spared no effort in promoting the project, and that the company will invest in establishing the largest Internet of Everything innovation business headquarters outside of the United States at the site to cover the Greater China region.

Beyond efforts to capture the U.S. smart cities market through imports and investment, Chinese technology companies also engage in aggressive lobbying efforts in the United States. ZTE and Hikvision have both pursued lobbying strategies designed to influence U.S. policy and public

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[480] Don Clark, "U.S. and Chinese Tech Firms Team Up on Sensor Networks for 'Smart Cities'," *Wall Street Journal*, May 12, 2016, https://www.wsj.com/articles/u-s-and-chinese-tech-firms-team-up-on-sensor-networks-for-smart-cities-1463081921.

[481] Don Clark, "U.S. and Chinese Tech Firms Team Up on Sensor Networks for 'Smart Cities'," *Wall Street Journal*, May 12, 2016, https://www.wsj.com/articles/u-s-and-chinese-tech-firms-team-up-on-sensor-networks-for-smart-cities-1463081921; Stefano Landi, "Chinese Academy of Sciences and Sensity Systems to Create Global Platform for Smart City Applications and Services," LinkedIn Pulse, May 14, 2016, https://www.linkedin.com/pulse/chinese-academy-sciences-sensity-systems-create-global-stefano-landi/.

[482] Dan Meyer, "Verizon Looks to Boost ThingSpace Internet of Things Platform with Sensity Deal," *RCRWirelessNews*, September 12, 2016, https://www.rcrwireless.com/20160912/carriers/verizon-looks-boost-thingspace-internet-things-platform-sensity-deal-tag2; Marlène Sellebråten, "Sensity Aims for China's Smart City Market," Enterprise IoT Insights, May 16, 2016, https://enterpriseiotinsights.com/20160516/smart-cities/sensity-chinas-smart-city-market-tag29.

[483] Don Clark, "U.S. and Chinese Tech Firms Team Up on Sensor Networks for 'Smart Cities'," *Wall Street Journal*, May 12, 2016, https://www.wsj.com/articles/u-s-and-chinese-tech-firms-team-up-on-sensor-networks-for-smart-cities-1463081921; Larry Dignan, "Itron Acquires Silver Spring Networks for $830 Million, Eyes Broader Smart City, Smart Grid Deployments," *ZDNet*, September 18, 2017, https://www.zdnet.com/article/itron-acquires-silver-spring-networks-for-830-million-eyes-broader-smart-city-smart-grid-deployments/; "Business Models for Smart City Projects," Guangdong Rongwen Energy Technology Group, 2017, http://www.rongwenest.com/aboutus/index.

[484] "2017 New Billion-Dollar Project for Guangzhou Smart City Construction: How Does Foreign Company CISCO Cut the Cake? (2017广州智慧城市建设新出千亿级项目 外企思科如何切得蛋糕？)," Xinhua, April 1, 2017, http://www.xinhuanet.com/info/2017-01/04/c_135954297.htm; "Cisco Partners with Plug and Play to Develop a Smart City in Guangzhou," Medium, June 27, 2018, https://medium.com/@PlugandPlay/cisco-partners-with-plug-and-play-to-develop-a-smart-city-in-guangzhou-fa1561fa41f0.

opinion, with ZTE employing former Nebraska Republican Congressman Jon Christensen and former Connecticut Senator Joe Liberman and Hikvision hiring former Senator David Vitter and Congressman Denny Rehberg, both Republicans.[485]

Implications for the United States

Global Competitiveness

If the United States is unable to maintain a significant foothold in global smart cities markets, particularly vis-à-vis China, it stands to face numerous challenges to its economic, foreign policy, and national security interests moving forward. Given the abovementioned global market trends and with demographics shifting toward urban centers, the technologies that will shape the smart cities of tomorrow will also constitute a wider swath of the future economy. Smart cities, however, will employ different technologies to meet goals tailored to individual cities. As a result, the implications of using smart cities technologies will depend on the portfolio of technologies chosen, the degree of interconnectivity among the systems, and the design of the technologies from the component to the system level, among other factors.

Most critical among smart cities technologies is 5G, which will not only spur the growth of smart cities by fostering greater interconnectivity and serving as the backbone of its IoT applications, but will also drive what many have deemed the "Fourth Industrial Revolution," bringing with it more innovation and stimulating economic growth with the benefits of scale.[486] While 5G systems provide connections to transfer information, the data 5G systems deliver comes from its network equipment. Smart cities equipment can include public and private databases such as government or hospital records; sensors and cameras that track the flow of people or resources; IoT devices including smart grid or smart water technologies; and smart transportation systems such as trains, ships, and public transit.

If the United States does not establish a lead in smart cities technology innovation and competitiveness, the economic implications include the potential permanent loss of a strong global high-tech market share and the risk of falling behind in emerging data-driven sectors such as AI due to the lack of adequate data sets provided by 5G networks. U.S. firms involved in other sectors relying on massive, high-speed connectivity such as self-driving vehicles or high-density video streaming would also find themselves at a global disadvantage.

The national security implications include a lack of domestic high-tech supply chains, potentially insecure communications networks, and lagging development of relevant defense technologies

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[485] Marcus Stern, "U.S. lobbyist severs ties with Chinese telecom ZTE," *Reuters*, August 9, 2012, https://www.reuters.com/article/us-zte-lobbyist/u-s-lobbyist-severs-ties-with-chinese-telecom-zte-idUSBRE87904020120810; Daniel Lippman and Steven Overly, "China's ZTE taps Joe Lieberman for D.C. damage control," *Politico*, December 13, 2018, https://www.politico.com/story/2018/12/13/zte-china-joe-lieberman-1031383; Lachlan Markay, "Congress Cut Off This Chinese Surveillance Firm, So Now It's Turning to K Street," *The Daily Beast*, August 27, 2018, https://www.thedailybeast.com/congress-cut-off-this-chinese-surveillance-firm-so-now-its-turning-to-k-street. Christensen stepped down when it was revealed that the FBI was investigating ZTE for selling telecommunications equipment to Iran. For more see: Marcus Stern, "U.S. lobbyist severs ties with Chinese telecom ZTE," *Reuters*, August 9, 2012, https://www.reuters.com/article/us-zte-lobbyist/u-s-lobbyist-severs-ties-with-chinese-telecom-zte-idUSBRE87904020120810.

[486] "Powering the Fourth Industrial Revolution with 5G," CityLab, 2018, https://www.citylab.com/sponsored/Verizon-FirstOn5G/powering-the-fourth-industrial-revolution-with-5g/211/; Elsa Kania, "Securing Our 5G Future," Center for a New American Security, November 7, 2019, https://www.cnas.org/publications/reports/securing-our-5g-future

such as autonomous systems. Furthermore, the increased production, transport, and aggregation of data provides unprecedented avenues for potential adversary intelligence collection. Accordingly, the U.S. ability to secure an edge in smart cities technologies will be critical to its future long-term economic health and maintaining its relative strength on the world stage.

Standardization and U.S. Foreign Policy Interests

The global standardization ecosystem is an arena where China has moved to strengthen its hand, both in formal international proceedings and in pursuing normalization through widespread adoption of Chinese products. This positioning strengthens China's market position at a cost to the United States and its companies. As discussed in Chapter 4, China has placed its representatives in key positions in international standards-making bodies, such as the ITU, to generate outcomes conducive to its interests. In contrast, the United States has taken a more peripheral role in these institutions.

If China is successful in reshaping international standards to suit its interests, broader U.S. foreign policy interests will be undermined. Standards produce path dependencies that will spur reliance on follow-on components and products. Thus, if China secures first-mover advantage on 5G in global markets, the quality or price of products offered by competitors carries less weight. Such a scenario would undercut U.S. efforts to promote its smart city technologies abroad, to the detriment of U.S. companies and counter to U.S. foreign policy goals.

If U.S. market access decreases, then so does the U.S. government's ability to promote democratic values and human rights through smart cities channels, undercutting the Trump administration's goal of shaping normative behavior in this field as well as the stated goal of providing a viable alternative to authoritarian models, to include the promotion of smart cities applications as developments for the benefit of the people rather than a government tool to monitor and control citizens.

Future Markets and Market Advantages

Globally, the market for smart cities technologies is expected to rapidly increase within the next five years. Industry reports generally portray projections with favorable assumptions regarding demand; one industry report predicts an expansion from $104.6 billion USD in 2018 to $222.3 billion USD by 2023 at a compound annual growth rate of 16.4 percent.[487] This growth is projected to spread out roughly evenly between North America (30 percent of total growth), Europe (35 percent of total growth), and the Asia-Pacific region (25 percent).[488] Industry analysts predict that transportation and traffic management, energy, water management, healthcare, public safety, and

[487] Comparing the results of this industry study with the much larger $1.1 trillion valuation Chinese consulting companies gave to the smart cities market in 2018 cited in Chapter 2 indicates that there are likely significant discrepancies in the scope of technologies included in measuring the "smart cities" market, or potential collapsing of the distinction between investment into smart cities development and the broader value of all commercial activity that could be classed as related to smart cities. This figure is roughly in line with the global market research estimates cited in Chapter 4 and could conceivably contain more moderate estimates of the size of the Chinese market.

[488] "Smart City Platforms Market by Platform Type, Service, Delivery Model and Region - Global Forecast to 2023," ReportLinker, February 1, 2019, https://www.reportlinker.com/p05748352/Smart-City-Platforms-Market-by-Platform-Type-Service-Delivery-Model-And-Region-Global-Forecast-to.html.

education will receive significant investment.[489] At this point, the market for smart cities platforms remains dispersed among many different competing firms.[490] Commonly identified major competitors include Huawei, IBM, Cisco, Siemens, AT&T, Siemens, Oracle, Microsoft, Schneider Electric, Hitachi, and Ericsson.[491]

Further, the primary focus of the smart city market has already begun to change, as companies shift from focusing on "first mover" countries to developing countries such as India and Vietnam, as the latter countries start investing more heavily in smart buildings, e-government apparatuses, and smart transportation.[492]

The amount of funding leading companies invest in research and development is a potential indicator of market growth in the future. With top Chinese companies pouring an average of 10 percent of their profits back into research and development (up nearly 45 percent from 2017 to 2018),[493] not counting government funding for national strategic priorities, they stand to continue making strides in smart cities technological development, something these companies have linked explicitly to plans for export to other nations participating in the Belt and Road Initiative.

National Security Risks and Responses

Recognizing the potential national security risks of incorporating insecure components into smart cities platforms and other systems, the Trump administration has taken recent steps to protect critical infrastructure in the United States. In May 2019, the administration labeled ICT imports to the United States a "national emergency" and levied Executive Order 13872 to restrict technology that "poses an undue risk," given that "foreign adversaries are increasingly creating and exploiting vulnerabilities in information and communications technology and services."[494] While the order

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[489] GlamResearch, "Smart Cities Market 2019 – Alcatel-Lucent, Bitcarrier, Cisco Systems, Ericsson, Firetide," Industryreports24.com, August 1, 2019, https://industryreports24.com/83892/smart-city-ict-infrastructure-market-trends-drivers-strategies-applications-and-competitive-landscape-2025/; "Smart Cities Market Analysis Report By Application (Governance, Buildings, Utilities, Transportation, Healthcare, Environmental Solution), By Region, and Segment Forecasts, 2019-2025," Grand View Research, May 2019, https://www.grandviewresearch.com/industry-analysis/smart-cities-market.

[490] The market research firm Mordor Intelligence defines "consolidated" marketplaces as those that are split between two to five competing firms, whereas dispersed or fragmented markets are "highly competitive, without any dominant players." Mordor Intelligence, "Smart Cities Market - Growth, Trends, and Forecast (2019 - 2024)," January 1, 2018, https://www.mordorintelligence.com/industry-reports/smart-cities-market.

[491] "Smart City Platforms Market by Platform Type, Service, Delivery Model and Region - Global Forecast to 2023," ReportLinker, February 1, 2019, https://www.reportlinker.com/p05748352/Smart-City-Platforms-Market-by-Platform-Type-Service-Delivery-Model-And-Region-Global-Forecast-to.html and Mordor Intelligence, "Smart Cities Market - Growth, Trends, and Forecast (2019 - 2024)," Mordor Intelligence, January 1, 2018, https://www.mordorintelligence.com/industry-reports/smart-cities-market.

[492] "The Status Quo of Global Smart City Development in 2018: Investment Focus Shifts to Post Development Countries Such As China and India (2018 年全球智慧城市发展现状：投资重点向中国、印度等后发国家转移)," ChinaBaoGao.com, September 25, 2018, http://free.chinabaogao.com/fangchang/201809/09253D3952018.html.

[493] Ma Si, "Top Internet Companies Hike R&D Spending," *China Daily*, August 15, 2019, http://global.chinadaily.com.cn/a/201908/15/WS5d548fefa310cf3e35565ca6.html.

[494] Wayne M. Morrison, "U.S. China Trade Issues," Congressional Research Service, June 23, 2019, https://fas.org/sgp/crs/row/IF10030.pdf; "Executive Order on Securing the Information and Communications Technology and Services Supply Chain," The White House, May 15, 2019, https://www.whitehouse.gov/presidential-actions/executive-order-securing-information-communications-technology-services-supply-chain/.

did not name China, the day it was announced, the Department of Commerce added Huawei to its BIS Entity List.

Other efforts, like the SECURE Technology Act,[495] signed into law in December 2018, established a Federal Acquisition Security Council as one of several measures aimed at mitigating supply chain risk. The Department of Homeland Security's Cybersecurity and Infrastructure Security Agency (CISA) has convened a government and industry Information and Communications Technology Supply Chain Risk Management Task Force, putting forward initial recommendations on security first steps like preventing purchases of counterfeit ICT technologies by incentivizing purchases from original equipment manufacturers and authorized resellers.[496]

These steps and others have had some effect. Hikvision's ability to continue to sell products to U.S. customers has been stunted by the fact that its products were banned by the federal government in the National Defense Authorization Act (NDAA) for fiscal year 2019, sending a clear signal to cities across the country that Hikvision products represent a security risk.[497] Missouri Representative Vicky Hartzler, a senior member of the House Armed Services Committee, added Hikvision to the NDAA, stating, "We must face the reality that the Chinese-government is using every avenue at its disposal to target the United States, including expanding the role of Chinese companies in the U.S. domestic communications and public safety sectors. Video surveillance and security equipment sold by Chinese companies exposes the U.S. government to significant vulnerabilities and my amendment will ensure that China cannot create a video surveillance network within federal agencies."[498]

Nevertheless, data and shipment records provided by Panjiva reveal that ICT technology from Chinese firms has continued to enter the U.S. market.[499] This includes items explicitly restricted in the NDAA such as telecommunications equipment from Huawei and ZTE and surveillance equipment from Hikvision and Dahua previously used in U.S. government facilities.[500]

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[495] Susan B. Cassidy, "Jumping to Exclusions: New Law Provides Government-Wide Exclusion Authorities to Address Supply Chain Risks," Inside Government Contracts, January 22, 2019, https://www.insidegovernmentcontracts.com/2019/01/jumping-exclusions-new-law-provides-government-wide-exclusion-authorities-address-supply-chain-risks/.

[496] "CISA's ICT Supply Chain Risk Management Task Force Makes Key Acquisition Recommendation," DHS.gov, June 20, 2019, https://www.dhs.gov/news/2019/06/20/cisa-s-ict-supply-chain-risk-management-task-force-makes-key-acquisition.

[497] "H.R. 5515 – John S. McCain National Defense Authorization Act for Fiscal Year 2019," Congress.gov, June 5, 2018, https://www.congress.gov/bill/115th-congress/house-bill/5515/text/pcs; IPVM Team, "First US City Bans Hikvision," IPVM, August 20, 2018, https://ipvm.com/reports/first-city-ban.

[498] Rodney Bosch, "Federal Ban on Chinese Video, Telecom Equipment Takes Effect," Security Sales and Integration, August 19, 2019, https://www.securitysales.com/emerging-tech/cybersecurity-tech/federal-ban-chinese-video-telecom/.

[499] Tailored Panjiva dataset provided by S&P Global.

[500] H.R. 5515- John S. McCain National Defense Authorization Act for Fiscal Year 2019, Pub. L. No. 115-232, 132 Stat 1636 (2019).

Conclusions and Areas for Future Research

Over the past decade, the advent of smart cities has promised to revolutionize nearly every aspect of municipal governance and urban living. Rapid proliferation of digital sensing and information networking technologies is expected to precipitate massive improvements in areas such as transportation, urban upkeep, energy grid management, and public safety through the collection of data to inform resource allocation and policymaking. As the world's second-largest economy and home to several of the world's largest cities, China's race towards full-scale implementation of smart cities using these technologies will generate profound impacts on its own population and the rest of the world.

Many of these impacts will occur by design. Smart cities are a linchpin of China's future economic and urban development strategies and are part of a decades-long pursuit of digitization and informatization designed to enhance China's comprehensive national power and cement the CCP's rule over China. Accordingly, smart cities development initiatives have received extensive support from both central and local authorities within China and are frequently focused on improving transportation, public safety, education, healthcare, and environmental protection. The use of smart cities technologies for public safety, for instance, extends the historical legacy of mass surveillance undertaken by the CCP and is likely to substantially improve the regime's mass surveillance capability should these technologies successfully overcome a number of lingering technical problems.

Other impacts of China's smart cities development extend beyond its borders to nations around the world, including the United States. Backed by the CCP and the state, Chinese companies are aggressively exporting all manner of smart cities technologies abroad, including critical network infrastructure and a wide variety of mass surveillance technologies, transforming themselves into industry leaders in the process. Some of these smart cities technologies have already been used in a variety of places in the United States, ranging from local municipalities to sensitive U.S. government facilities, raising questions about possible security threats posed by Chinese products in the United States. The bottom-up nature of how the United States coordinates smart cities development policy makes communities susceptible to adopting smart cities devices from Chinese manufacturers, which are regarded as less secure and more vulnerable to technical compromise or exploitation on legal grounds by the Chinese government.

Even as U.S. policymakers become more cognizant of the potential economic and security challenges Chinese smart cities development poses, there is almost no systematic, publicly available quantitative data to inform policy that could mitigate these challenges. A comprehensive accounting of the penetration of Chinese equipment into U.S. and international smart cities efforts would not only help identify and quantify potential security risks but also identify potential markets for U.S. companies to compete in both at home and abroad.

This report represents an initial step in understanding the economic and security ramifications of China's smart cities development. Further steps are needed to develop policy that can improve U.S. competitiveness in this sector, including better public information on the size and scope of China's presence in U.S. smart cities development. As smart cities continue to mature in China, the United States, and around the world, the United States cannot afford to concede its leading position as a developer of smart cities.