A New "Great Game?": China's Role in International Standards for Emerging Technologies

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About This Report

Section 9414 of the National Defense Authorization Act (NDAA) of 2021 directs National Institute of Standards and Technology (NIST) to enter into an agreement with an appropriate entity to conduct a study and provide recommendations with respect to the effect of policies of the People's Republic of China (PRC) and coordination among industrial entities within the PRC on international bodies engaged in developing and setting international standards for emerging technologies. Through a collaboration with Makwa Global, this report studies the PRC's impact on international standards for emerging technologies and makes recommendations as appropriate.

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ABBREVIATIONS

Abbreviations used in this report are summarized in the table below:

Abbreviation	Definition
3GPP	3rd Generation Partnership Project
4G	Fourth-Generation Wireless
5G	Fifth-Generation Wireless
AG4	Advisory Group 4
AI	Artificial Intelligence
AI4A	Focus Group on Artificial Intelligence (AI) and Internet of Things (IoT) for Digital Agriculture
AI4EE	Focus Group on Environmental Efficiency for Artificial Intelligence and other Emerging Technologies
APEC	Asia-Pacific Economic Cooperation
AQSIQ	The General Administration of Quality Supervision, Inspection and Quarantine
ATIS	Alliance for Telecommunications Industry Solutions
AUI	Affective computing user interface
AWI	Approved Work Item
BDDN	Big Data Driven Networking
BDRA	Big Data Reference Architecture
BIS	Bureau of Industry and Security
BRI	Belt and Road Initiative
BRICS	Brazil, Russia, India, China, and South Africa
CAC	Cyberspace Administration of China
CAE	Chinese Academy of Engineering
CAICT	China Academy of Information and Communications Technology
CAS	Chinese Academy of Sciences
CASIC	China Aerospace Science and Industry Corporation
CATR	Chinese Academy of Telecommunications Research
CBHD	China Blue High-definition Disc
CESI	China Electronics Standardization Institute
CETC	China Electronic Technology Group Corporation
CICT	China Information and Communication Technologies Group Corporation
CNITSEC	China Information Technology Security Evaluation Center
COIT	Colegio Oficial Ingenieros de Telecomunicación
CSIC	China Shipbuilding Industry Corporation
DIS	Draft International Standard
DVD	Digital Video Disc
EMF	Electromagnetic Fields
ETRI	Electronics and Telecommunications Research Institute
FG	Focus Group
FVCN	Future Vertical Communications Networks
GSI	Global Standards Initiative
ICT	Information and Communications Technology
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
IMT-2020	International Mobile Telecommunications-2020
IOACAS	Institute of Acoustics, Chinese Academy of Sciences

Abbreviation	Definition
IoT	Internet of Things
IP	Internet Protocol
ISO	International Standardization Organization
ITU	International Telecommunication Union
JSON	JavaScript Object Notation
JTC	Joint Technical Committee
KAIST	Korea Advanced Institute of Science and Technology
KPI	Key Performance Indicators
LLC	Limited Liability Corporation
MCIT	Ministry of Communications and Information Technology
MIIT	Ministry of Industry and Information Technology
ML	Machine Learning
MOST	Ministry of Science and Technology
NA	Not Applicable
NDAA	National Defense Authorization Act
NIST	National Institute of Standards and Technology
PRC	People's Republic of China
Q	Question
QAI	Quantum Alliance Initiative
QIT4N	Quantum Information Technology for Networks
QKD	Quantum Key Distribution
QKDN	Quantum Key Distribution Networks
QoS/QoE	Quality of Service/Quality of Experience
RAN	Radio Access Network
RFI	Request for Information
RMB	Renminbi
SAC	Standardization Administration of China
SAMR	State Administration of Market Regulation
SC	Subcommittee
SC&C	Smart Cities and Communities
SCP	Smart City Platform
SDG	Sustainable Development Goals
SDO	Standards Development Organizations
SG	Study Group
SNRA	Sensor Network Reference Architecture
SQL	Structured Query Language
SSO	Standards-setting Organizations
TC	Technical Committee
TF	Task Force
TMN	Telecommunications Management Network
TR	Technical Report
TS	Technical Specification
TSAG	Telecommunications Standardization Advisory Group
TSR	Technical and Strategic Review
UAE	United Arab Emirates
UAV	Unmanned Aerial Vehicle
UK	United Kingdom
US	United States

Abbreviation	Definition
WAPI	WLAN Authentication and Privacy Infrastructure
WG	Working Group
WLAN	Wireless Local Area Network
WTSA	World Telecommunication Standardization Assembly

Introduction, Key Findings, and Recommendations

Globally recognized standardization is a foundational mechanism for international trade and economic development. Internationally agreed-upon technical standards set specifications and processes that improve the functionality, security, compatibility, and interoperability of goods and services used around the world. Agreement on technical vocabularies, processes, specifications, and systems of measurement among industry and academia can expedite research collaboration, improve compatibility of products and services across borders, remove trade barriers, and reduce research, production, and supply chain costs. The benefits precipitated by international standardization will be especially prominent in critical emerging technologies like artificial intelligence and quantum information science, among others.

China is increasingly involved in international standards bodies and stands to make a significant impact on standardization in a variety of emerging technologies. Once a relatively esoteric topic reserved for academics and technical personnel, international standardization has attracted increasing scrutiny over the last half decade, especially as China's role in the creation and adoption of international standards has expanded since its admittance into the World Trade Organization in 2001. China's emergence as a dynamic engine of global economic growth and technological innovation, as well as its status as one of the most important markets in the world, provide ample motivation to better understand its participation in international standardization efforts.

Despite the increasing attention paid to China's expanding role in international standardization, the actual facets of its efforts remain difficult to accurately characterize, especially in emerging technologies. The effect of China's standardization strategies on international standards development bodies, however loudly trumpeted, remains unclear. Further, while China's participation in international standards bodies over the last decade can be documented to some extent, the quality or value of that participation is still a subject of debate. As a result, whether international standards for select emerging technologies are being designed to promote Chinese interests to the exclusion of other participants remains mostly unknown, through previous Chinese standardization practices in international standards organizations may yield some insight into future Chinese participation in these organizations and the implications that may result.

This report addresses these information gaps in four main sections. It begins by briefly outlining the ends, ways, and means underpinning China's involvement in codifying international standards and its pursuit of emerging technologies. Next, the report characterizes China's impact on international standards bodies and standardization efforts in selected emerging technologies, summarizing different types of participation and proposing a working methodology for further assessment. The third section of the report describes implications and possible futures for standardization in emerging technologies given China's strategic efforts and its past activities. Finally, the report concludes with some recommendations on how the United States might address the influence of the People's Republic of China and bolster United States public and private sector participation in international standards-setting bodies.

This report finds the following:

- The most prominent recent expression of China's broader goals in international standardization are found in the "National Standardization Development Outline" (国家标准化发展纲要), which is the culmination of a years-long project called "China Standards 2035."
- The Outline characterizes standardization as a means to reinforce national comprehensive competitiveness and expedite economic and social development and stresses its value in advancing China's economic development, supporting technological innovation, "opening up" China to the world, and—less explicitly—bolstering national security.
- The Outline and "China Standards 2035" emphasize a number of methods for turning Chinese aspirations to influence and shape global technical standards into concrete reality. Official sources encourage active participation in the International Standardization Organization (ISO), International Electrotechnical Commission (IEC), and International Telecommunication Union (ITU), proposing more work items, forming new organizations, and accelerating internationalization of Chinese technical standards in new energy, new materials, quantum computing, smart manufacturing, industrialized construction, and engineering.
- Official Chinese documents suggest a heavy emphasis on quantitative measures of success, including the number of Chinese-held positions in international standards bodies, the number of Chinese standards converted to international standards, the number of votes expected and cast to complete international standards, and the number of international standards led or participated in by Chinese representatives, among others.
- Chinese international standardization efforts have been funded by steadily increasing but still opaque government outlays. These expenditures include both specific carveouts to pay for fees at international standards organizations, along with vague provisions for foreign aid.
- The Chinese government provides substantial subsidies at multiple levels of governance to encourage entities to get involved in creating standards, offering the highest payments and awards for its experts and organizations who contribute to international standards.
- The Chinese government considers artificial intelligence, quantum computing, integrated circuits, brain-like intelligence technology, biotechnology, deep space, new energy and materials, and smart transportation to be the most important emerging technology areas for international standardization.
- Despite the international nature of ITU and ISO and the prestige they hold, a systemic lack of transparency in international standards organizations makes measuring any trends in standardization challenging.

- China's disproportionately high – and increasing – rate of participation in ITU-T through Contributions and Work Items is particularly notable in contrast with ISO, where no single country is as dominant as China is in ITU. China takes advantage of non-competitive opportunities for participation to dominate the system through number of leadership positions held and sheer number of proposals. In the aggregate, the figures for both have increased over the last decade.
- Available ISO reports indicate that Chinese presence in the body has increased both in terms of the number of secretariats and convenorships over the past decade, but China's progress in ISO standards formation is comparatively untracked, as ISO does not provide either country-of-origin or country-specific authorship or editorship information.
- Overall, China has attempted to steer the standardization of emerging technology areas through quantitative dominance of leadership positions and number of Work Items, especially in ITU. Perhaps more notable, however, for many of these technologies, China has arguably asserted influence not in *number* of recommendations but in *importance* by steering foundational standards work in roadmaps, overviews, reference architectures, terminologies, and general specifications.
- Ultimately, however, China's apparent quantitative dominance in certain international standards organizations may belie its actual effectiveness in influencing international standards. International standards experts have complained in the recent past that China's representatives often submit large numbers of low-quality proposals that neither solve real problems nor propose real solutions and are often not technical in nature.
- While China benefits from substantial influence over standards development for some of its chosen technology areas in ITU, or competes with Korean and Japanese members for dominance in others, U.S. representatives have competed directly with China in a few, select fields. While the United States generally expends significantly less energy in ITU than China does, it has a proven ability to gather political capital, cooperate with partners, and check undesirable standardization practices when it so chooses.
- China's sub-national participation in international standards work includes a variety of different organizations, ranging from state-backed standardization think tanks to corporate behemoths like Tencent and Huawei to research institutes from China's defense-industrial base and companies that have been sanctioned by the United States either for posing a threat to U.S. national security or for violating human rights abroad. The participation of Chinese defense research institutes and intelligence organizations in international standardization is likely in part an expression of technical prowess encouraged by China's strategy of military-civil fusion.
- Chinese influence in international standards-setting is likely to vary by body and subcommittee/working group. The vast majority of industry experts and other stakeholders who participate in international standards setting activities believe

that ISO and IEC, two of the three most prominent standards-setting bodies, have sufficiently robust rules, governance systems, and safeguards in place to prevent China (or any other single actor) from exerting outsized influence in a systemic way. The notable exception is ITU-T, which industry associations and think tanks point to repeatedly as the body where Chinese state influence in the standards-setting process for emerging technologies can be felt most keenly.

- While anxiety over the rapid expansion of China's membership and leadership roles within some standards bodies may be overblown, this report's own analysis finds that careful monitoring of subcommittees and/or working groups on critical and emerging technology areas under ISO, IEC, and ISO/IEC JTC 1 is warranted.
- China is likely to maintain consistent gains in *de facto* standardization. China's standards export initiatives serve as a mutually reinforcing complement to its strategy of increased engagement in international standards setting bodies.
- Chinese efforts in international standardization could lead to Chinese standards dominance in some emerging technologies as well as the bifurcation of technical standards in these areas.

The report makes the following recommendations:

- Make additional funding to international standards organizations contingent upon publication of author metadata and standards uptake information.
- Fund education efforts for participants in international standards organizations to give them more context on their foreign counterparts and the roles and missions of their respective home organizations.
- Promote further development of educational materials on best practices for international standards-making bodies.
- Convene like-minded countries, companies, and other stakeholder entities to develop routine auditing processes for international standards creation.
- Encourage foreign talent to come to the United States to learn and train on standards development practices.
- Commission a research effort to understand the barriers that may be holding back U.S. participation in international standardization work.
- Clarify existing export control regulations that could accidentally discourage U.S. companies from participating in standards development.
- Establish closer collaboration between the United States government and standards development organizations.
- Provide funding to host more international standards development meetings in the United States, including major gatherings.
- Provide consistent funding to sustain U.S. participation in international standards organizations.
- Establish funding for small businesses to participate in international standards development through tax incentives and grants.

Ends, Ways, and Means: Chinese Involvement in International Standards and the Pursuit of Emerging Technologies

China's leadership has made abundantly clear that it views the development and evangelization of new technology standards as an integral component of developing China's strength as a great power. Statements from Chinese Communist Party leadership have explicitly labeled standards development an indispensable component of enabling the PRC to take full advantage of the "great changes not seen in a century" (百年未有之大变局) that it perceives to be occurring in the international sphere.[1, 2] For instance, since his ascension to CCP leadership in 2013, Xi Jinping has repeatedly stressed that the world is currently undergoing a new industrial revolution which provides a "rare opportunity to catch up with the established world powers" (赶超世界强国的难得机遇).[3] A corollary to this assertion is the notion that encouraging adoption of Chinese standards within the international sphere will ideally situate the PRC to compete within this new industrial paradigm.

This view is neatly encapsulated by a speech delivered by Xi to a 2014 conference held by the Chinese Academy of Sciences. In his comments he declared that China should take a proactive role in "laying the foundation" (打基础) of the new economic arena as a means of crafting the new agreed upon "competition rules" (竞赛规则).[4] In the context of any discussion of international standardization, the PRC clearly does not view winning the standards race as a direct means of developing discrete advantages or capabilities. Rather, dominance in international standards is a means of empowering China to exercise outsized influence on the world industrial landscape and world affairs writ large, in the same way that the United States' leadership in automation and information technology enabled it to shape the 20th century.

China's approach to international standardization is fundamentally led by the state governance apparatus which is ultimately subservient to the whims of the ruling Chinese Communist Party. Within this ostensibly unitary, statist approach, however, is a byzantine array of government departments with varying remits for harnessing and regulating standards both inside and outside China. As a result, China's standardization efforts are not guided by a monolithic strategy document, but instead characterized by numerous overlapping government directives and justified by decrees from China's top leaders and central economic planners. Most of the discourse from within this complex governing apparatus focuses on China's domestic standardization efforts as a matter of economic development. Comparatively little official ink has been spilled on the status and results China's international standardization efforts, a fact that encumbers deeper analysis. In fact, much of the existing literature assessing China's international standardization strategy relies upon analytic inference or interviews with standardization experts.

While many of China's broader intentions regarding international standardization can be inferred from its activities or the statements of Chinese practitioners, the most reliable of these myriad views on China's ultimate goals in international standardization are found in official documents. In their most final forms, these documents bear out consensus views of China's objectives in international standardization efforts. Even if the

most candid or informative examples are not publicly available, official Chinese publications offer valuable insight into the thematic goals underpinning China's involvement in international standards.

Much of China's recent emphasis on international standardization is driven by long-running efforts to overhaul, modernize, and harness its domestic standardization system for economic and strategic gain, especially after the country acceded to the World Trade Organization in 2001. National standardization reform plans describe a past Chinese standardization system lacking in coordination and rife with repetition and contradiction, with government and market roles misplaced, among other faults.[5] These deficiencies yielded undesirable results in early Chinese participation in international standardization efforts. In particular, China's unsuccessful attempts to develop standards in information and communication technologies in the mid-2000s, like the pushes for Wi-Fi alternative WLAN Authentication and Privacy Infrastructure (WAPI) and DVD alternative China Blue High-definition Disc (CBHD), laid bare the challenges of global competition in international standardization.[6]

China's state-level standardization authorities began to adjust their efforts accordingly. A 2013 cross-department effort to accelerate China's development of the Internet of Things (IoT) included a "Standards Formulation Special Action Plan" (标准制定专项行动计划) that called for Chinese government agencies to "increase [Chinese] influence and competitiveness in international standards" by forming project groups for IoT international standards, promoting the formation of standardization organizations corresponding to international or regional standardization organizations, submitting proposals in international fora, and "fighting for" leadership positions within international standards organizations, among other activities. These specific standardization actions were to be undertaken to support a "healthy and orderly development of China's IoT industries" by sustaining applied usage of the IoT as well as continued technical and process innovation.[7] All of these objectives spoke to a larger desire to reap the economic benefits of influence in international standards.

By 2017 and 2018, direct public articulations of China's objectives in international standardization had begun to appear in more general official documents covering more than just a few selected industries. The January 1, 2018 revision to the 1988 Standardization Law, for instance, called for the state to encourage participation in international standardization, "promote the adoption of international standards in the Chinese context," and "harmonize Chinese and foreign standards."[8] That same year, China's Standards Administration Commission (SAC), the General Administration of Quality Supervision, Inspection and Quarantine (AQSIQ), and the Chinese Academy of Engineering (CAE) kicked off a "China Standards 2035" project to reform Chinese standardization efforts both at home and abroad.[9] An initial two-year research effort ("National Standardization Development Strategy Research" (国家标准化发展战略研究)) resulted in a summary document "2020 Main Points of National Standardization Work" (2020 年全国标准化工作要点) that articulated strategic priorities and imperatives.[10,11]

Perhaps the most prominent recent expression of China's broader goals in international standardization are found in the "National Standardization Development Outline" (国家标准化发展纲要), which built upon the 2020 Main Points and the previous years of research and consensus-building surrounding Chinese standardization work. The Outline acknowledges standardization as a means to reinforce national comprehensive competitiveness and expedite economic and social development, as well as the fundamental role that standards play in promoting high-quality development, supporting high-tech innovation, and spurring "opening up" to the outside world in order to build China into a "modernized socialist country."[12] Among the many objectives described in the Outline, it stresses key thematic goals that improved international standardization efforts could actualize, including advancing China's economic development, supporting technological innovation, "opening up" China to the world,[13] and—less explicitly—bolstering national security.

METHODS FOR ACHIEVING CHINA'S INTERNATIONAL STANDARDIZATION GOALS

These aspirations have been translated into more concrete methods by which the Chinese strive to influence international standards. The "2020 Main Points of National Standardization Work" (2020 年全国标准化工作要点) highlights several of the ways by which China's standards experts should achieve the above goals using international standardization, including:[14]

- Deep participation in the governance of international standards organizations, namely by "fulfilling the duties of permanent members of ISO and IEC" (理事国) and sharing Chinese practices and proposing Chinese plans to "improve the ability to transform or govern within international standards organizations."
- Increased participation in the "official business and decision-making of international standards bodies."
- Expanding international cooperation and "accelerating the internationalization of superior Chinese technical standards in the fields of new energy, new materials, quantum computing, smart manufacturing, industrialized construction, and engineering."
- Participating in the formulation of international standards, proposing more work items, promoting the formation of new international technical standards organizations, and "increasing the quality and capability of Chinese personnel in international standards organizations."

While some of these methods are rather general, other documents make no pretense about the advocacy role that Chinese standardization experts are expected to play. A sample constitution for those aspiring to form Chinese standardization committees includes among several recommended activities an exhortation to "undertake the drafting of international standards and actively recommend Chinese standards to become international standards at the behest of the SAC."[15]

Perhaps the most concrete expression of methods can be inferred from related bureaucratic paperwork that Chinese standards experts complete. SAC reporting forms

solicit a variety of details from Chinese standardization personnel that highlight both the main categories of methods for gaining influence in the international standards arena and the metrics for success. This information is shown in the table below.[16]

Table 1: Metrics of Influence in International Standards Creation, Developed by SAC

Category	Metrics
International Standards Transformation (国际标准转化情况)	• Number of corresponding (对口) international standards • Number of international standards transformed into National or industry standards • Number of international standards incorporated into national and industry planning • Number of international standards unsuitable for transformation
Positions Held in International Standardization Organizations (国际标准化组织任职情况)	• Number of chairs held in ISO/IEC (主席) • Number of vice chairs held in ISO/IEC (副主席) • Number of ISO/IEC secretaries (秘书) • Number of ISO/IEC registered experts (注册专家)
International Standards Formulation (国际标准制定情况)	• Number of international standards formulations led (主导) • Number of international standards formulations participated in (参与)
International Standards Voting (国际标准投票情况)	• Number of votes expected to complete international standards (应完成) • Number of votes actually cast to complete international standards (实际完成)
International Standardization Meetings (国际标准化工作会议情况)	• Number of international meetings attended • Number of personnel sent to international meetings • Number of international meetings held in China • Number of personnel attending international meetings held in China
Translation of National Standards into Foreign Languages (完成国家标准外文版翻译情况)	• Number of National Standards translated into English • Number of National Standards translated into foreign languages other than English • Total number of National Standards translated
Application of National Standards Abroad (国家标准在海外转化应用情况)	• Number of National Standards used by regional organizations • Number of National Standards used by other national standardization organizations • Number of National Standards used in important projects

Documents like the ones referenced above strongly suggest that China's international standardization efforts are characterized by a systematic bureaucratic focus on quantifiable metrics for success. These metrics are frequently tied to budget lines and

expenditures that provide concrete indicators of the Chinese government's standardization priorities.

MEANS TO MANY ENDS: FUNDING CHINA'S INTERNATIONAL STANDARDIZATION PRIORITIES

Budgets and outlays represent the business end of China's standardization strategy, matching ends and ways with the means to accomplish them. China's international standardization efforts are funded through a variety of sources. SAC reporting forms for Chinese standardization personnel, for instance, indicate that participants can obtain their funding from a "national standards revision and formulation subsidy (国家标准制修订补助经费), outlays from relevant government departments and industry associations, subsidies from local governments, and investment funds from organizations that hold a secretariat billet (秘书处承担单位的经费投入).[17] While the national standards revision subsidy is reserved for purchases of international standards for translation[18] and further detail about investment funds is difficult to find, information about some of the other funding sources suggest a steadily increasing budget and a remunerative system that is adapting to the requirements laid out by the China Standards 2035 effort.

Funds from relevant national-level government departments also likely play a vital role in implementing China's standards strategy. Though detailed figures and breakdowns by department and by bureau were not publicly available, an analysis of State Administration of Market Regulation (SAMR) budget documents from its 2018 incorporation of the SAC to the present year indicated a steady increase in its funding for "foreign relations outlays (外交支出)," a catch-all term that encompasses a variety of different costs including fees for ISO and IEC, as well as line items for "external aid" (对外援助) and "other foreign relations outlays" (其他外交支出).[19] More detailed descriptions of these line items are not made publicly available, and these budgets are not likely entirely dedicated to SAMR's international standardization efforts. Nevertheless, data from these documents show that these expenditures have increased over the last decade and began to spike after 2018.

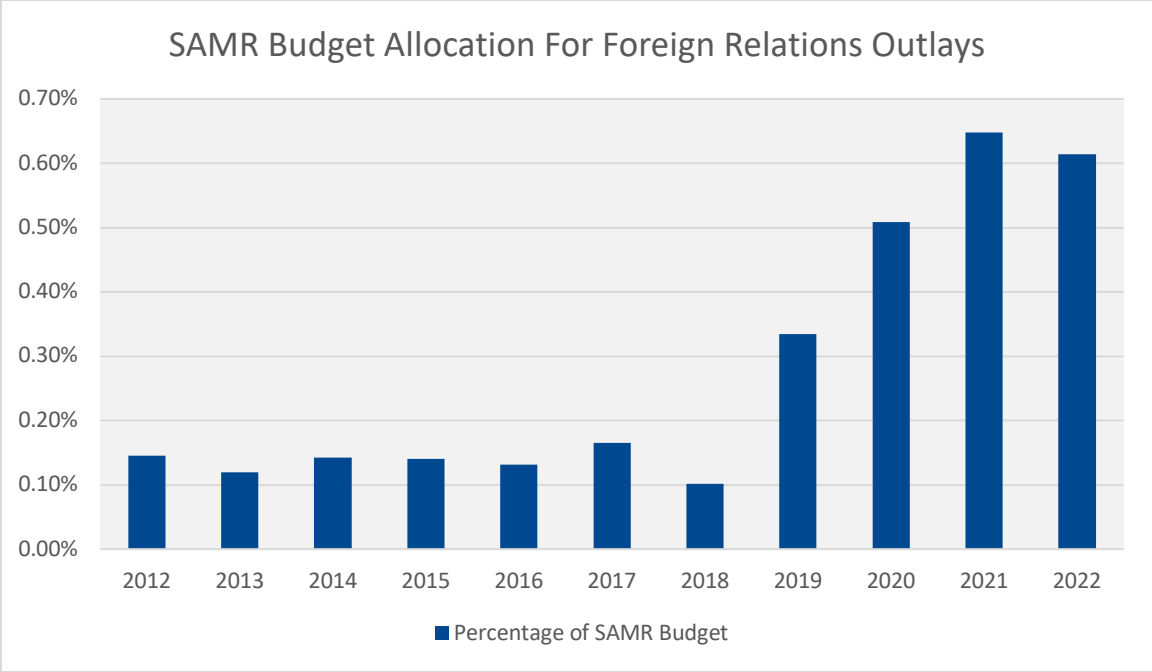


Figure 1: SAMR Budget Allocation for Foreign Relations Outlays.

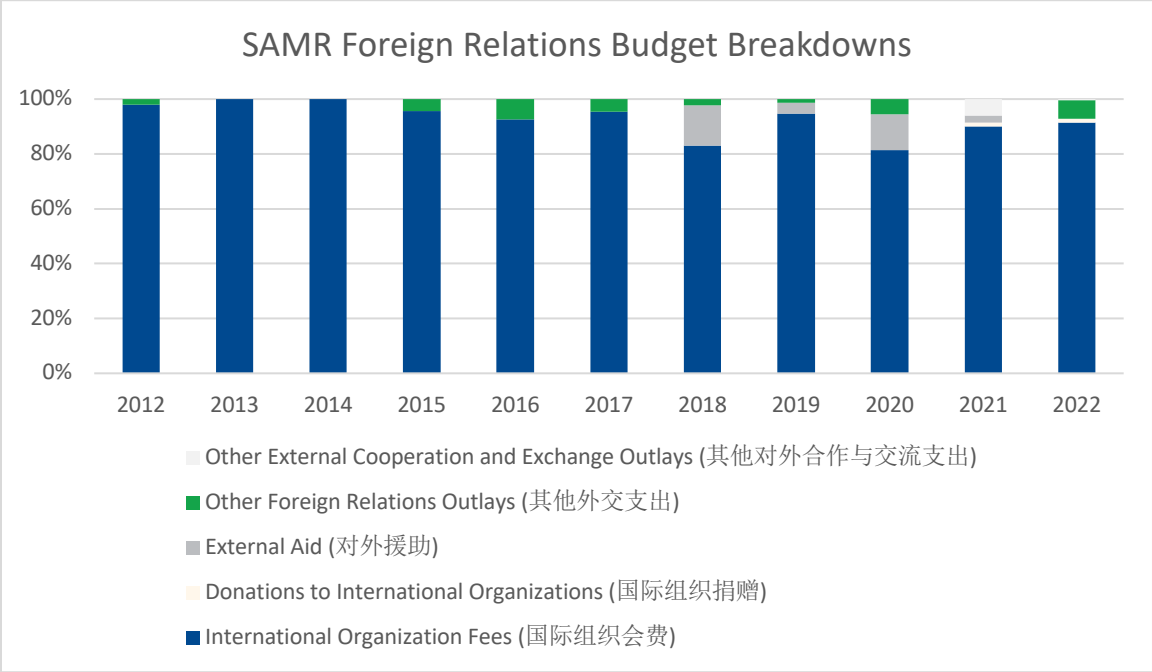


Figure 2: SAMR Foreign Relations Budget Breakdowns.

Local government subsidies are yet another avenue by which the Chinese government supports its international standardization objectives. These financial incentives have increasingly been adapted to the demands of the National Standardization Development Outline, offering payments to a wider range of organizations that contribute to standards formulation and other standardization work. For

instance, a March 2022 circular from the Chaoyang District of the Beijing Municipal Government offered subsidies to any "enterprises, public institutions, societal organizations, cooperatives, and collective industrial and commercial households" that demonstrably contributed to standardization work. The circular offered different payments for different standard types, perhaps hinting at the relative importance and comparative difficulty of different types of standardization work: at the top of the scale were direct payments up to 30,000 RMB for any organization that participated in the formulation of an international standard.[20]

Chinese standardization efforts in the international arena may be backed by other funding sources not specifically listed in SAC forms. China's standardization apparatus also offers state awards and prestige to those who make substantial contributions to China's international standardization efforts. The thrice-revised China Standards Innovation Contribution Prize Management Rules (中国标准创新贡献奖管理办法) lay out the conditions (if not the actual cash amounts) for awarding prizes to exemplary performers. Honors are granted specifically to individuals and organizations that make outstanding contributions to "promote China's economic and societal development, secure health and security, protect the environment, and protect national interests." Those Chinese experts who have served in billets at ISO, IEC, and ITU are afforded special consideration both as nominators and as potential recipients of state awards.[21]

China's International Standardization Efforts and Emerging Technologies

China has adopted a full court press approach to standards development, with a particular emphasis on codifying regulations for emerging transformative technologies. In official documents such as the National Standardization Development Outline, China's state planners have laid out a fairly comprehensive vision detailing their priorities and goals for standards development.[22] The preponderance of documents like the Outline deal with ongoing efforts to codify standards for technologies which have reached a baseline level of maturity, such as transportation and communications infrastructure.[23] However, they also contain language which provides guidance for researching new standards for emerging technologies which are at the cusp of development, but which currently lack widespread commercial applications. While there does not appear to be a precisely enumerated list of priorities for standards development, the Outline does highlight five core areas in which standards research should be focused.[24] Broadly speaking these include artificial intelligence, quantum computing, biotechnology, new-generation information technology (e.g. blockchain technology, big data applications, and informatized industrial applications), and transportation technologies.[25]

There is a strong degree of overlap between emerging technologies slated for expedited standards development and technologies which have been flagged as priority research targets for China's state-planned economic sectors. A cursory comparison of the National Standardization Development Outline, the 14th Five Year Plan for economic development, and the industrial policy document Made in China 2025 Initiative reveals that prioritization for new standards development in emerging fields closely aligns with targets set for incubating "frontier science and technologies" (科技前沿).[26] The convergence of these research and development priorities appears to indicate that China

is pursuing a policy whereby standards development and actualization of emerging technologies go hand in glove. Functional research will enable China to achieve first mover advantage in the "fourth industrial revolution."

At the same time, developing a range of prefabricated standards increases the likelihood of those standards being adopted internationally, ensuring that foreign markets are primed for the adoption of Chinese products. This approach is in sync with efforts already laid out by PRC economic planners. For instance, the National Standardization Development Outline explicitly notes that China should utilize its influence in forums such as Asia-Pacific Economic Cooperation (APEC), the Belt-Road Initiative, the BRICS (Brazil, Russia, India, China, and South Africa) summit, and ISO to push for the adoption of its preferred technology standards.[27]

Table 2: Comparison of China's Technology and Standardization Priorities

Technology Type	Mentioned in the National Standardization Development Outline[28]	Mentioned in the 14th Five Year Plan "Frontier Technologies" Section[29]	Mentioned in the "Made in China 2025" Program[30]
New Generation Artificial Intelligence	Yes	Yes	Yes
Quantum Computing	Yes	Yes	Yes
Integrated Circuits	Yes*	Yes	Yes
Brain Science and Brain-Like Intelligence Technology	Yes*	Yes	Yes*
Genetics and Biotechnology	Yes	Yes	Yes*
Clinical Medicine and Health	Yes	Yes	Yes
Deep Space, Deep Earth, Deep Sea, and Polar Exploration	No	Yes	No
Smart Transportation	Yes	No	Yes
Energy and Materials Science	Yes	No	No

**Indicates that the text does not use a precise term of art to describe a technology in the corresponding row but uses terminology that identifies the core functions of the technology in question.*

China's development of standards for core frontier technology areas appears to be making steady progress, occurring largely in tandem with the functional development of the technologies themselves. At present, marking the exact progress of the development of these standards remains difficult. For instance, the National Standardization Development Outline does not assess the progress being made to standards related to the five core technology areas mentioned earlier in this section.[31] This stands in contrast to its evaluations of the progress of standards development for mature technologies such as communications equipment, which include detailed qualitative assessments of progress that has been made, as well as identifying areas for improvement.[32] This lack of specificity is unsurprising, given that technologies such as artificial intelligence (AI) and

quantum computing are still in their nascent stages and are far from reaching widespread commercial and industrial application. However, an examination of development efforts in the five core areas mentioned earlier in this chapter apparently confirms the notion that the PRC industrial planners are pursuing a fast-tracked approach to drafting standards governing frontier technologies. While the following list is not an exhaustive survey of all standards which have been drafted, it provides a snapshot of the current state of development in priority technology areas.

Artificial Intelligence

China's market for Artificial Intelligence (AI) appears to be rapidly approaching maturity. AI has been frequently flagged by Party leadership as being a latchkey technology, having the potential to pay a range of dividends in fields ranging from systems management to leadership decision-making.[33] Consequentially, institutions conducting both exploratory and functional research into AI applications have benefited from generous government subsidies.[34] This has resulted in the emergence of a robust and complex ecosystem of firms offering AI-related products, ranging from industry giants like Alibaba and Baidu to boutique startup outfits.[35]

The PRC appears to be on track towards developing a comprehensive slate of standards related to artificial intelligence by the middle of this decade. In 2020 the PRC released its "Guidelines for the Construction of National New Generation Artificial Intelligence System Standards." [36] This document was commissioned at the behest of the Central Party Committee and State Council, and was co-written with input from the National Standardization Administration, CAC, the National Development and Reform Commission, the Ministry of Science and Technology (MOST), and Ministry of Industry and Information Technology (MIIT).[37] Collectively, the guidelines lay out a detailed road map for the construction of a standards apparatus for AI-related technologies by the mid-2020s. The document declares that by 2021, stakeholders should "clarify the top-level design of AI standardization measures (人工智能标准化顶层设计), study the general principles of [AI] standards system construction and development (研究标准体系建设和标准研制的总体规则) and conduct preliminary research work in 20 key technology areas."[38] It goes on to assert that by 2023, an initial AI standards system should be established focused on urgently needed applications such as big data management and systems related to factors such as manufacturing, transportation, finance, and security.[39]

Quantum Computing

Out of all the technologies identified by the PRC as core frontier technologies, quantum computing is likely the furthest from achieving widespread commercial application. Currently the preponderance of research into quantum computing applications in China is carried out by state-funded universities, indicating that the technology is still relatively early in its development cycle and is reliant on government subsidies in order to conduct baseline research.[40] Nevertheless, outlets affiliated with the PRC's science and technology base appear to be optimistic about the trajectory of its quantum computing development, with at least one recent statement from CAS declaring that is "roughly on par with the West" in terms of its level of quantum research.[41]

Standards relating to quantum computing appear to still be in a nascent stage of development. For example, SAC/TC578, China's standards group in charge of developing standards for quantum computing, only began drafting standards for basic quantum computing terminology and definitions in 2020.[42] Ancillary materials released by TC 578 in April of 2022 stressed the "urgent need" for more standardized terms and definitions related to quantum computing, to "lay a solid foundation for the future standardization of quantum computing technology" (为量子计算技术标准化工作打下坚实的基础).[43]

Biotechnology

China's biotechnology market appears to be on the cusp of emerging as a major industry player, both domestically and internationally. A summary of biotechnology innovation progress during the 13th Five Year Plan released by MOST declared that major progress had been made in researching key technologies related to biotechnology, and that a "relatively complete biotechnology innovation system" had begun to take shape (基本形成较完整的生物技术创新体系).[44] It went on to assess that China's biotechnology industry was well on its way to maturation and had the capacity to compete internationally.[45]

The development of China's biotechnology sector has been accompanied by the establishment of several basic standards governing the industry. State planners within the PRC have made significant progress towards developing standards governing biotechnology throughout the mid-2010s. This has thus far included the release of standards governing basic terminology, as well as methodologies related to genetic engineering and other life sciences.[46]

New-Generation Information Technology

As with AI, China's information technology industry has achieved tremendous growth within the past ten years as a result of extensive government support and innovation within China's technology sector.[47] Through initiatives such as the Thirteenth and Fourteenth Five Year Plans, the PRC has sought to achieve a kind of vertical integration within its technology sphere, with the eventual goal of ensuring that it has the capacity to produce hardware and software domestically.[48] At the same time major technology firms such as Huawei have engaged in substantive developmental research into emerging applications.[49] As a result, China counts itself as an international leader in next generation information technologies such as big data management, IoT, and mobile technologies.[50]

Throughout the late 2010's and early 2020's, PRC state planners have made significant progress in drafting standards for emerging information technology applications. For example, within the past two years SAC/TC28 has released a number of concrete guidelines on big data management while SAC/TC124 has codified standards relating to "intelligentized" manufacturing development.[51] It appears likely that these efforts will continue as applications related to new-generation information technologies continue to proliferate.

Transportation Technologies

The PRC has made major strides in the past decade towards retrofitting next-generation technologies into its transportation networks. This growth has featured the development of new hardware capabilities (e.g., electronic vehicles), as well as the use of software to rationalize and improve the efficiency of China's existing transportation systems through IoT and smart cities development.[52] It is likely that this trend will continue into the 2020s, as more Chinese cities follow the lead of epicenters such as Shanghai and Tianjin in "informatizing" their transportation capabilities.[53]

The progress of transportation-related standards is difficult to quantify, as the relevant technologies are partly reliant on legacy platforms and have a large degree of overlap with other frontier technology groups. However, it is notable that standards development plans for other frontier technologies (e.g., artificial intelligence) include carve-outs for incorporating frontier technologies into existing transportation systems.[54] Additionally, within the past five years a number of draft standards for new-generation transportation systems have been published, such as those governing unmanned aerial vehicles (UAVs) and other uncrewed systems.[55]

As the preceding data points indicate, industry planners within the PRC are apparently sanguine about the construction and dissemination of standards for core technologies, even those which are comparatively immature. It is worth noting that the accelerated timeline under which these standards are being constructed could indicate that SAC and its attendant bodies are willing to accept sub-optimal industry guidelines, so long as they are drafted quickly enough to achieve "first mover advantage" within the international sphere. At present, most standards development in the aforementioned sectors appear to be aimed towards creating a common operating framework for industry stakeholders within the PRC. However, past examples such as the PRC's development of 5G standards would seem to indicate that this is merely a prelude to the evangelization of the China's standards abroad.

Assessing the PRC's Impact on International Standards Bodies and Standardization in Emerging Technologies

Criticisms abound over China's practices within international standardization organizations, as the Chinese government directly supports Chinese companies to meet the country's strategic needs. U.S. and Chinese technical standardization processes are systematically different. Whereas U.S.-led standards are voluntarily set up by companies in open, self-regulated, industry-led processes, Chinese standards are ultimately supported by the government as a component of national strategy to accomplish national goals and to exert Chinese influence.

This section examines Chinese behavior within two major international standards organizations, the standards body of the International Telecommunications Union (ITU-T) and the International Standards Organization (ISO), measuring changes in personnel and Contributions to assess the extent to which China has affected the development of standards over the past decade. The first section considers overall patterns in each standards body, assessing organization-wide impacts of Chinese involvement. The second considers China's success in steering standards on specific emerging technology areas, to build an understanding of how China's increased influence on international standards formation changes the development of specific technologies of interest.

Limitations and a Lack of Transparency

Despite the international nature of ITU and ISO and the prestige they hold, a systemic lack of transparency in international standards organizations makes measuring any trends in standardization challenging. Among other idiosyncrasies in data publication described below, neither ITU nor ISO publish a standard's development history; the editors, authors, and contributors are not published along with the text of the standard, nor is there a public record of voting or discussion surrounding the standard. This opacity makes it difficult to assess trends in international standards-making over time.

For its part, ITU provides many different types of data for public use, but makes crucial working documents available only to members, and removes Editors and Supporting Members from final texts. The only full-text that ITU makes publicly available is Recommendations; they provide metadata records only for Work Items and Contributions (full text is only available for paying members of ITU). Meeting details and working information are similarly unavailable to the general public. This working information is necessary to determine the extent to which Contributions are accepted and incorporated into resulting Recommendations. Notably, while Work Items and Contributions specify Editors and Supporting Members, these names are removed from the final Recommendations. By removing authorship records from approved documents, ITU makes this data less transparent – and less useful for tracking country participation.

ISO, in contrast to ITU, provides little to no data publicly; even purchased standards provide no authorship information, and working documents are not available for sale. In the absence of this information, authorship data can be pieced together but the results provide only a fragmentary indication of what trends could be. In some cases, media reports claim that Chinese authors drafted certain standards. In others, working

groups provided information on lead editors for specific projects. In all, however, ISO does not provide sufficient or consistent authorship data to perform any sort of quantitative analysis of trends over time.

Obscuring the development history of accepted standards makes it nearly impossible for oversight organizations to track trends like the dominance of a specific country, voting bloc, or company. This report used various workarounds to manually recreate authorship records, including leveraging media reports, identifying Work Items that developed into Standards, and using webpages maintained by standards organizations to track personnel participation. The extent to which authorship could be identified through supplementary research differed between ITU and ISO, as seen in the sections that follow.

MEASURING CHINA'S INCREASING INFLUENCE IN ITU

Over the past decade, Chinese entities have dramatically increased their involvement in the International Telecommunication Union (ITU) and its standards body, known as ITU-T. Since 2012, the number of Chinese members in ITU has increased six-fold with the number of China's submissions -- or in ITU parlance "Contributions" -- to ITU rising 25 percentage points. China's rise is such that it now has more members in ITU-T than the United States and is now a sponsor or co-sponsor of the majority of items submitted to ITU-T.

China's high rate of participation in supporting Work Items has led to a high rate of Chinese-supported Recommendations, largely thanks to ITU's high rate of approval for established Work Items. China's disproportionately high – and increasing – rate of participation in ITU-T through Contributions and Work Items is particularly notable in contrast with ISO, where no single country is as dominant as China is in ITU.

This section illustrates that China has established its ability to influence ITU Recommendations at every level, by overwhelming the system with the sheer quantity of members, leaders, Contributions, and Work Items. In an organization that is nominally one-country, one-vote, China has managed to use numbers to dominate deliverables.

CHINA'S MEMBERSHIP IN ITU

In the last decade, China has seen a six-fold increase in its ITU membership, jumping from a membership less than one-fifth the size of the U.S. contingent to membership numbers that meet, and in the case of ITU-T, outpace U.S. participation, as seen in the graphics below. As of December 2012, China had 16 members* in ITU

* ITU defines a company's nationality as the country it is headquartered in. For example, Huawei subsidiary Futurewei is based in the United States and is considered a U.S. company in ITU statistics, not a Chinese one.

compared to the United States' 114. As of July 2022, the figures are 106 for China and 118 for the United States.†

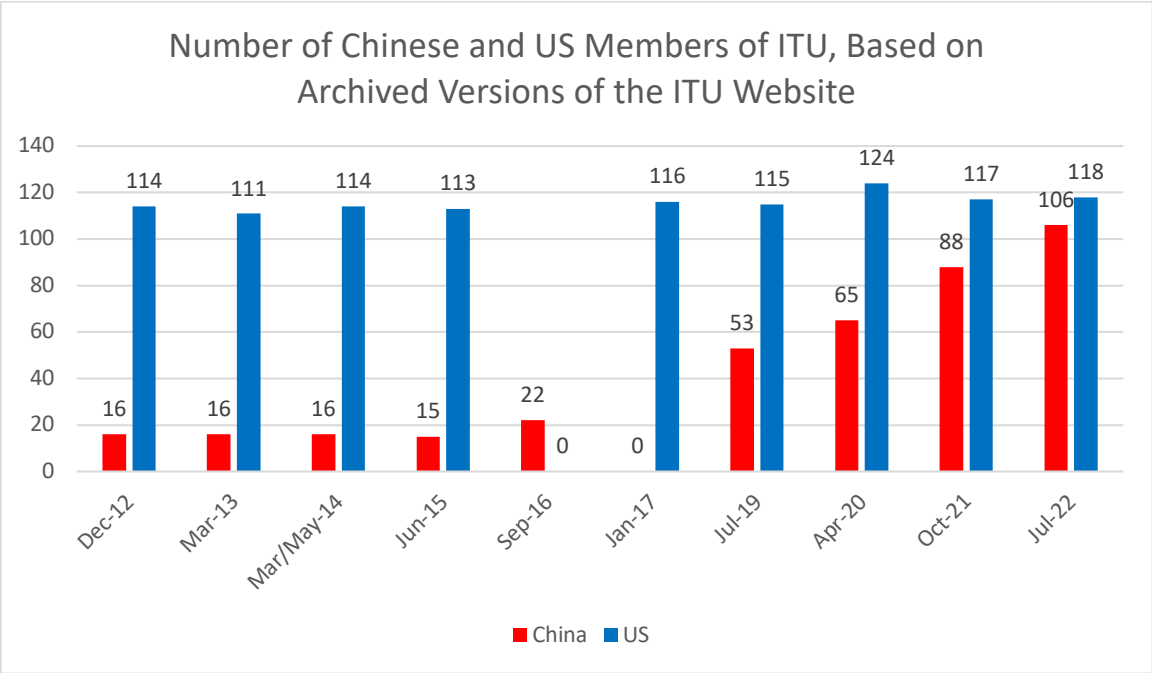


Figure 3: This graph shows the total number of Chinese members in ITU since 2012, with the U.S. figures provided for context. The figures include sector, associate, and academia members, and includes membership in all three branches.

When the same data set is used to look specifically at China's membership in ITU's standards body, ITU-T, a similar increase can be seen, with China surpassing the United States in the most recent figures: China currently has 95 ITU-T members, and the United

† Methodology: The numbers below were taken from historical copies of ITU membership lists on the organization's website, as archived by the Archive.org's Wayback Machine. The Wayback Machine has not archived the ITU website on a regular schedule so the figures available do not follow a set annual pattern.

From 2012 to 2015, the figures represent the aggregation of two lists: one list of all sector and academia members from a particular country, and a list of all associate members from a particular country. In one case – 2014 – the two lists (sector/academic members and associate members) were archived in different months, March and May.

Beginning in 2016, ITU's website gives a single list of all entities from a particular country, but the lists for the US and China were not archived in 2016 and 2017, respectively, meaning there is a four-month gap between the information available for the two countries for that period. Moreover, neither country's membership list was archived at all in 2018.

States has 83.‡ This rapid increase reflects a coordinated Chinese effort to engage more actively in ITU-T standard formation.

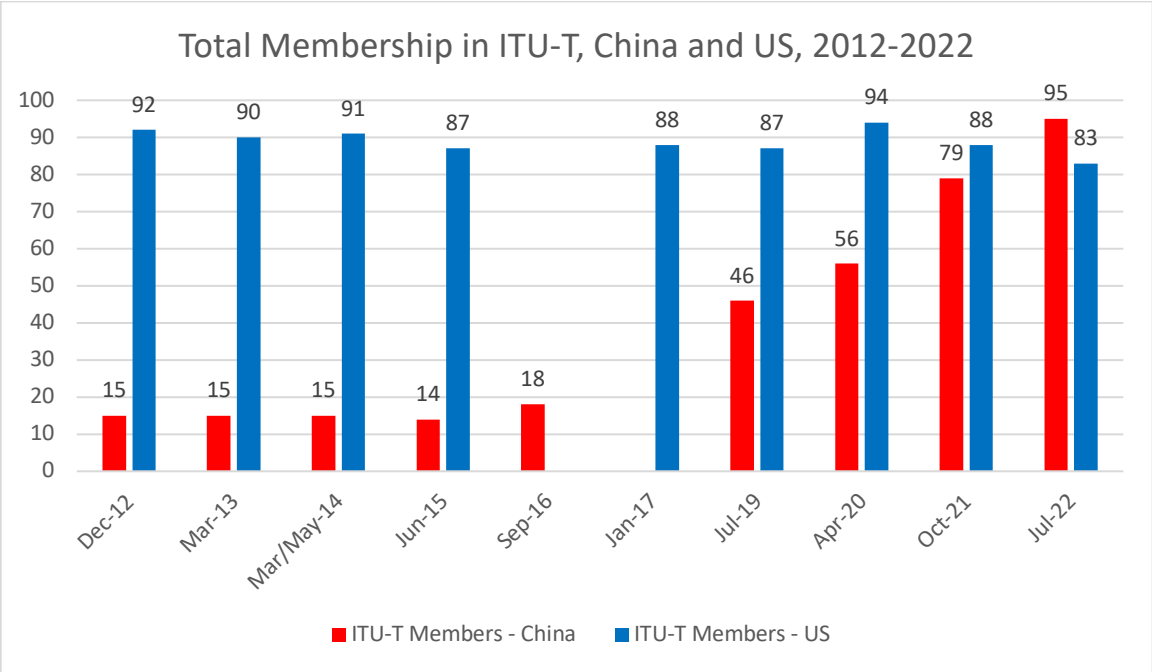


Figure 4: Total Number of U.S. and Chinese Members in ITU-T from 2012 to 2022.

China's increasing membership in ITU-T has been fueled primarily by increases in associate and academic members, who have slightly less autonomy than sector members, but pay lower membership fees. In 2019, China had 12 associate members and 13 academic members. As of July 2022, those numbers stand at 31 and 37, respectively. China's sector membership, on the other hand, rose only from 20 to 26 in the same period. By way of comparison, the United States has similar numbers of sector and associate members as China, but has only 11 academic members, compared to China's 37, as summarized in the table below.

Table 3: Breakdown of Chinese and U.S. ITU-T Members, July 2022

	ITU-T Total Members (July 2022)*	ITU-T Sector Members (July 2022)	ITU-T Associate Members (July 2022)	ITU-T Academia Members (July 2022)
China	95	26	31	37

‡ The total figures include government administrative bodies: MIIT for China, and four US government agencies.

United States	83	29	39	11

* *The total members figures include one state administrative entity for China and four state administrative entities for the United States that are not counted in the sector, associate, or academia member categories.*

CHINA'S LEADERSHIP IN ITU

China's jumps in membership have correlated with a dramatic upswing in leadership rates, particularly at the working level. China's dominance at ITU follows a specific pattern: China overwhelms the system with members and Contributions when participation is non-competitive and non-exclusive but remains within the normal range (on par with other highly involved countries) when participation is competitive. Consider China's rate of participation at various levels of ITU leadership. At the Study Group Chair level, China's leadership presence appears no more numerous than other actively involved countries. Study Group leadership appears to be distributed widely, with no countries holding more than two of the 11 chairmanships. China, Korea, and Japan all held two chairmanships during the 2017-2021 Study Period.[56] In the 2022-2024 Study Period, China only held one Chairmanship.[57] By contrast, however China holds many Vice-Chairmanships – approximately one per Study Group.[58] Vice-Chairmanships appear mostly non-competitive, with five or more per Study Group, which allows for almost all interested parties to participate.[59]

This trend continues at the working level, where Question leadership is much less competitive. In the 2017 to 2021 Work Period, 56 of the 81 Questions addressed by ITU-T (69%) had a Chinese rapporteur or associate rapporteur.[60] Only 20 Questions did not have a Chinese rapporteur or associate rapporteur; the remaining five had no listed leadership.[61]

The next section explores trends in Chinese activities within ITU in more detail, focusing on key emerging technology areas. The relative effects of Chinese leadership at each level remain unstudied; it is still unclear whether leadership at the working level (editors or rapporteurs) is more meaningful than leadership at higher levels (chairs or secretariat positions). This is a suggested area for future research.

CHINA'S CONTRIBUTIONS TO ITU

In Contributions, as in working-level leadership, China takes advantage of non-competitive opportunities for participation to dominate the system through sheer number of proposals. ITU-T members can participate in the ongoing, daily work of the organization by submitting "Contributions." This section follows ITU's lead in using the term "Contributions" to describe items submitted for consideration by ITU-T's eleven study groups (or SGs), which are the primary units that carry out ITU-T's mission. ITU's website does not appear to define the term "Contributions," but based on a review of the organization's work, the term is synonymous with submissions, and is used to refer to virtually any kind of item a study group might formally consider, including new technical recommendations, revisions to existing standards, term definitions, corrections and amendments, proposed evaluation metrics, comments on proposals, and all other such items.

Over the past decade, Contributions sponsored or co-sponsored by China have made up a significant percentage of all Contributions submitted to ITU-T. China has outpaced the United States in submitting Contributions to ITU study groups every year. As of 2021, Chinese entities sponsored or co-sponsored a majority of all Contributions to ITU study groups – 53 percent.[62] The percentage of ITU study group Contributions made by United States entities, meanwhile, has hovered consistently around the 10 percent mark from 2012 to 2021, ranging from seven percent to around 14.[63] China's prevalence in submitted items is also evident in aggregate: whereas the United States submitted between approximately 150 to 250 items each year from 2012 to 2021 (data for 2022 is incomplete), China's total annual Contributions have ranged from 448 in 2012 to 1,055 in 2021.[64] These figures are shown in the figure below.

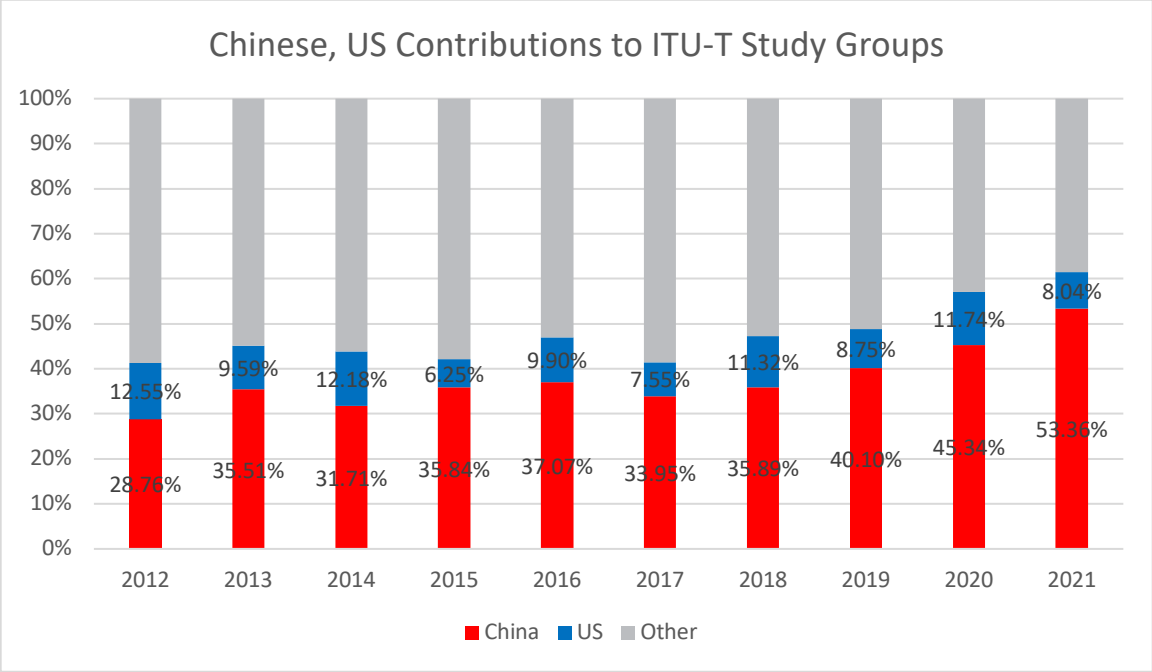


Figure 5: Number of Contributions by Chinese and U.S. Entities to ITU-T Study Groups. See Appendix 1 for breakdown of Contributions by Study Group.

CHINA'S WORK ITEMS IN ITU

This report has thus far assessed the extent to which China has favorable conditions in place to propose, support, author, and pass Recommendations by covering its leadership presence and its activities in ITU. In the section that follows, we address whether the considerable infrastructure that China has established to support its standardization efforts has led to increased Chinese influence over passed Recommendations.

To answer this question, the report uses ITU's public records of "Work Items" to track the progress of Chinese-sponsored projects from draft to approval. ITU maintains records of previous "Work Items," which can be Technical Reports or Recommendations, in its "Work Program," tracking the status, current text, editors and Supporting Members working on proposed recommendations in each study group. To identify the extent to which Chinese entities are participating in and guiding the development of new ITU

standards, analysts studied the rate of Chinese entities as Supporting Members, comparing Chinese participation to that of other countries, tracking participation over time, and examining dominance in specific sectors.[§]

Of ITU-T's 2,766 work items in progress between 2017 and 2022, across all sectors, Chinese companies were involved as "Supporting Members" in 646, approximately 23%.[65] However, the bulk of the work items do not have Supporting Members at all (1774, or 64%). Of the work items that cite *any* Supporting Members, **China participates in more than 65%.** This number has also increased year-over-year; using binomial regression, analysts determined that the likelihood that a recommendation has Chinese supporting members increases by more than 3% over each passing year; by January of 2022, the likelihood that a recommendation would have Chinese supporting members was 77.65%, a 17-point increase from the January 2017 likelihood of 60.3%.[66]

This participation is driven by the dominance of a few Chinese state-backed information and communications technology (ICT) entities. Of the eight entities that participated in at least 100 different Work Items within the studied timeframe, all but one was Chinese.[67]

Table 4: Entities who have supported more than 100 work items between 2017 and 2020. Of the eight companies who topped this threshold, all but one was Chinese.

Supporting Member Name	*Is a Chinese Entity*	*Number of Supported Work Items*
Huawei	TRUE	274
China Unicom	TRUE	248
China Telecom	TRUE	204
China Mobile	TRUE	189
ZTE	TRUE	189
Electronics and Telecommunications Research Institute (ETRI)	FALSE	185
MIIT	TRUE	131
China Information and Communication Technologies Group Corporation (CICT)	TRUE	109

[§] In later sections of the report, Editors are considered as well as Supporting Members. Given the size of the Work Program dataset, manual coding of all Editors as Chinese or non-Chinese was not feasible. As a result, this section only considers Supporting Members.

China's approach of maximizing the number of Work Items that it participates in effectively increases its impact; Work Items are usually accepted, so increasing the number of Work Items China participates in is tantamount to increasing the number that get approved. Of the 2766 Recommendations that were developed between 2017 and 2022, only two were "not approved" (a different status from merely "discontinued" or "carried over" into the next session); neither of these were sponsored by China.[68]

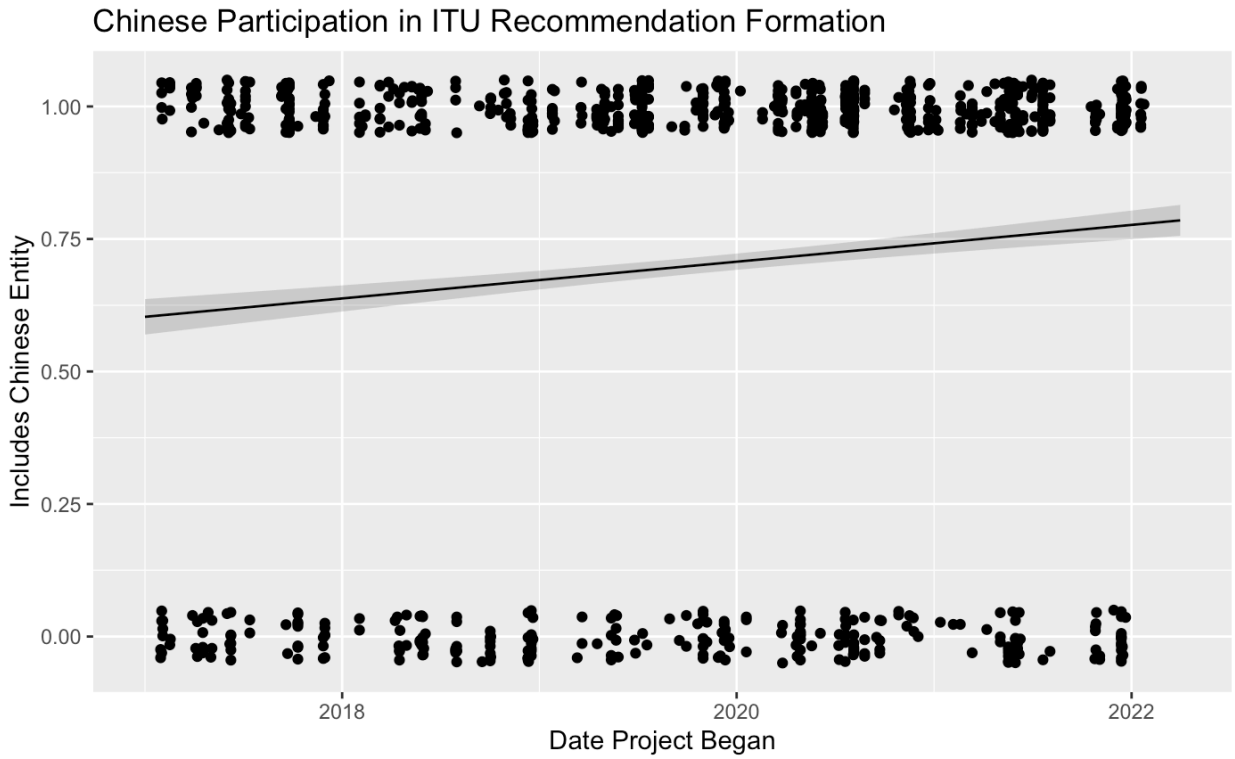


Figure 6: The likelihood that a newly established work item (represented in dots) had a Chinese sponsor increased at a statistically significant rate between 2017 and 2022. For each passing year, the logistic regression model shows that the likelihood a new recommendation would have Chinese supporting members increased by 3% ($p<0.001$), leading to a 17% increase over the five studied years. See Appendix 2 for a breakdown of work items by study group and rapporteur.

CHINA'S SMALL BUT GROWING GAINS IN ISO

While China's growing influence in ITU is stark, its climbing influence in ISO appears much less self-evident. This is due in part to a lack of transparency about standard authorship from ISO. However, even in leadership roles – which ISO does break down by country – China does not numerically dominate, perhaps because there are no non-competitive leadership roles.

Nevertheless, China's more moderate rise in ISO should not be overlooked simply because it is not as extreme as in ITU. ISO standards are widely adopted by developing and developed countries and are thus highly influential. Moderate gains in influential technical areas, as discussed in the following section, could presage a significant Chinese impact on the international standardization environment.[69]

CHINA'S LEADERSHIP IN ISO

Available ISO reports indicate that Chinese presence in the body has increased both in terms of the number of secretariats and convenorships over the past decade. Meanwhile, for the United States the number of secretariats and convenorships have decreased overall during that period. This is based on data in ISO annual reports (published from 2015 to 2020),[70] ISO "*In Figures*" publications, and ISO membership data. (Other data available in the accompanying spreadsheet include the number of meetings held annually by Technical Committees (TCs) and Subcommittees (SCs).) ISO's website provides more recent data for secretariats, but not convenorship data.

The number of secretariat positions within TCs, SCs, and convenorships is an important measurement of a country's influence within ISO. The number of China's secretariat positions has risen in the last decade, with the country holding 79 in 2019; this was followed by a decrease in 2020 (to 66), and then a slight growth in 2021, to 68[71]. The number of China's secretariat positions increased from 68[72] positions in November 2021 to 76[73] as of 7 July 2022. Previously, Chinese-led technical committees or subcommittees in the International Organization for Standardization increased 75 percent from 2011 to 2019.[74]"

The graph below represents the number of secretariat positions at the TC and SC level held by China and the United States from December 2012 to July 2022. Overall, the number of secretariat positions held by China has risen year-over-year, (with the exception of 2020). Meanwhile, the number of secretariat positions at the TC/SC level held by the United States has decreased steadily over the past decade.

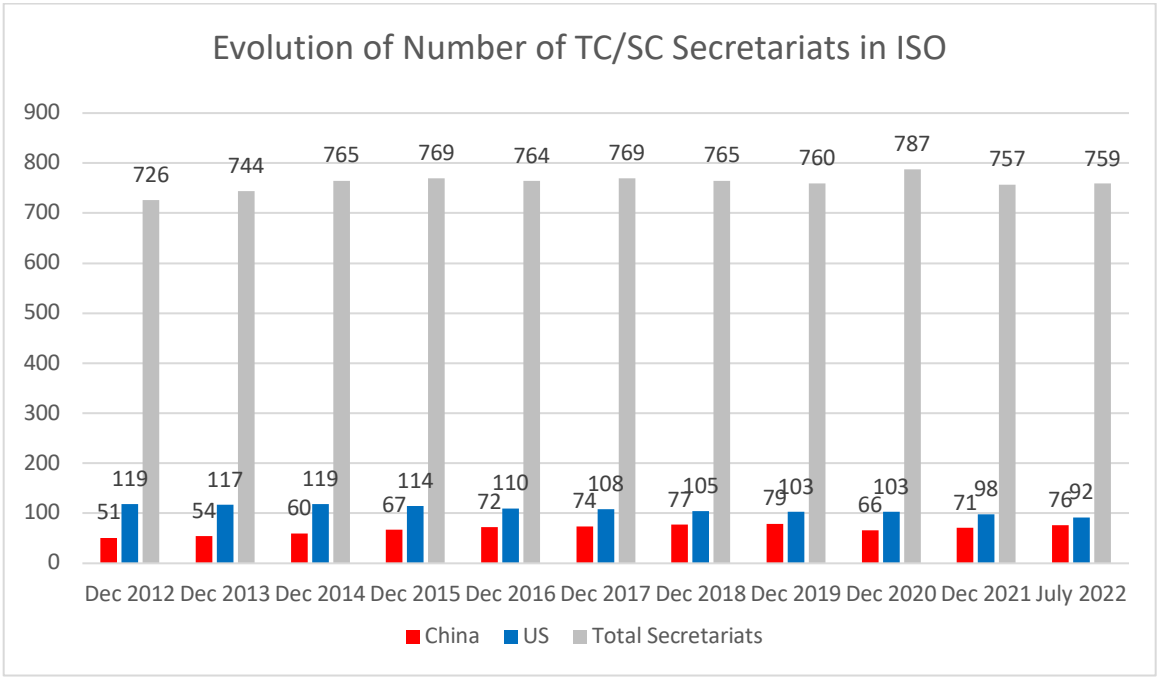


Figure 7: Comparison of US-held and China-held secretariats from 2012 – 2022, with the overall number of secretariats at the ISO each year for reference.

Based on ISO's *"In Figures"* publications, the number of secretariat positions held by China rose from 51 in December 2012 to 76 as of July 2022. The number of US secretariats decreased from 119 to 92 during the same period. For reference, the total number of secretariats increased from 726 secretariats in 2012 to 759 as of July 2022.[75]

The figure below demonstrates the progression of convenors held by China and the United States within Working Groups (WG) from 2012 to 2022. Data includes the total number of convenorships during the last decade (data for 2022 is incomplete due to a lack of availability).

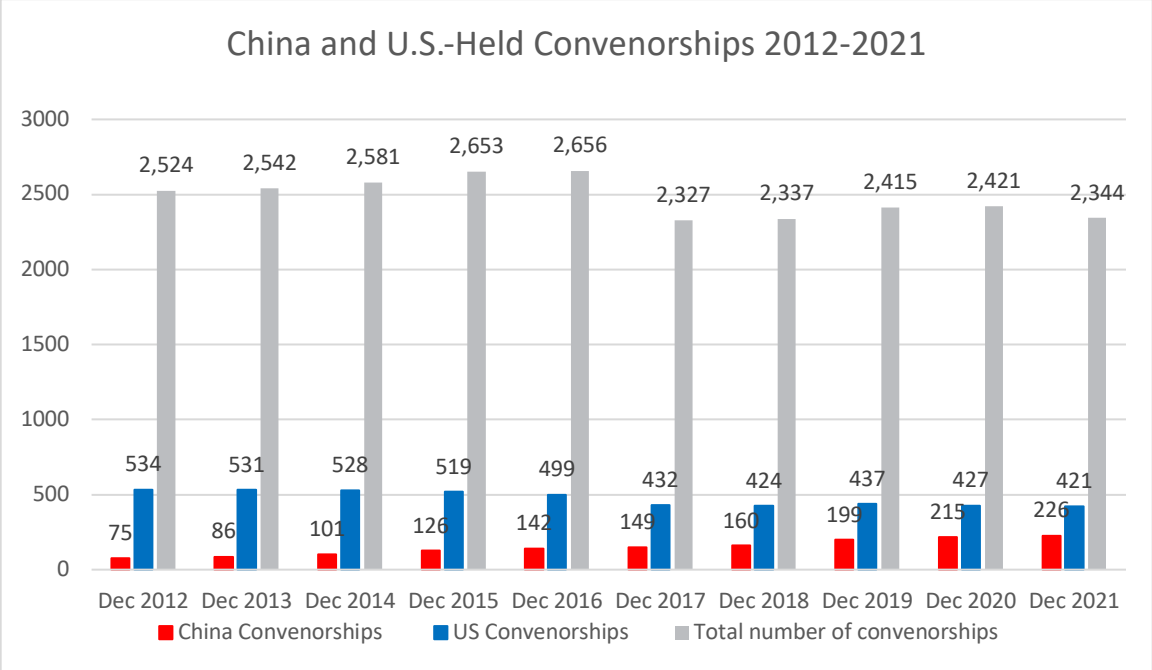


Figure 8: Comparison of US-held and China-held convenorships from 2012 to 2021 (data for 2022 was not complete). The chart includes the overall number of convenorships at the ISO each year for reference.

The number of convenorships held by China over the past decade has steadily increased, based on ISO *"In Figures"* publications. The number of convenorships held by the US decreased steadily year-over-year during that timeframe, primarily due to a decrease in the number of secretariats.[76]

CHINA'S UNTRACKED PROGRESS IN ISO STANDARDS FORMATION

ISO does not provide information on accepted standards' country of origin or national authorship/editorship rates for standards. Data on which editors wrote which standards is available only anecdotally. Some subcommittees provide editor information[77] or full Work Program information for subsets of standards in progress,[78] while other subcommittees provide no country-specific data at all.[79] This lack of formal data is puzzling, especially given that country or international organization of origin is specified for officers and participants, and underlying data is provided on number of members and number of countries.

The next section of this report provides an answer to the question of *whether* China is successfully authoring new, influential standards in ISO. However, answering the question of *to what extent* requires a dataset that is not publicly available. This underscores the pressing need for greater transparency from international standards organizations, particularly when the necessary data is already collected for internal purposes.

THE EFFECTS OF THE PRC'S STANDARDS STRATEGY ON EMERGING TECHNOLOGY STANDARDS

While the previous section attempted to assess increasing Chinese influence in ISO and ITU from an organizational level, that tactic is better suited for assessing China's *efforts* to increase influence, rather than their actual *effects* on standards. This section considers overall patterns in China's impact on emerging technologies standards from both ISO and ITU. A more detailed accounting of China's international standardization activity in emerging technologies is available in Appendix 3 of this report.

Overall, China has succeeded in steering the standardization of emerging technology areas in a few aspects. The first is quantitative dominance; in some of these areas, China wrote the vast majority of approved ITU Recommendations, and is editing most of the upcoming ITU Work Items. In many cases, China holds more leadership roles than any other countries, particularly working-level leadership roles. Chinese companies submitted hundreds of relevant Contributions, drastically outnumbering other voices.

More notably, however, for many of these technologies, China has asserted influence not in *number* of Recommendations but in *importance*. For most of the relevant technical areas, China steered some of the most foundational and potentially influential Recommendations: roadmaps, overviews, reference architectures, terminologies, and general specifications. China engaged early on these technologies, pushing for the establishment of dedicated Study Groups and Focus Groups, and dominated the first Recommendations published. Even as voices have since diversified, China has controlled the course of development by steering the most foundational standards. In short, China has worked to define the language that is used to discuss emerging technologies and set the first roadmaps for their standardization.

CHINA'S PATTERN OF INVOLVEMENT: FROM INTRODUCTION TO MATURITY

For many key areas of interest, China has developed a predictable pattern of involvement in ITU, and, to a lesser extent, in ISO. First, China's representatives propose studies on areas of interest, lead a related Focus Group, and continue holding leadership positions as the item becomes the focus of a Study Group. For many of China's top areas of interest such as 5G, the Internet of Things, and smart cities, China has shepherded standardization processes from introduction to maturity. One interesting example of this *modus operandi* is the development of smart city standards in ISO: China recommended the formation of a Smart City Study Group, led said Study Group, and then proceeded to hold every leadership role in the ISO body for smart cities from its formation until the present.

China recommended the establishment of a Study Group to research smart cities in a 2013 proposal called "China Contribution on Possible Future Work on Smart Cities in [Joint Technical Committee] JTC 1."[80] This proposal was accepted and led to the formation of the Study Group on smart cities at the 28th ISO/IEC JTC 1 plenary in France in November of 2013.[81] Yuan Yuan of CESI (China Electronics Standardization Institute) was appointed as the convenor, and Liu Tangli (also from CESI) was appointed as the secretary for the Study Group (SG).[82,83]

Two years after the formation of the Study Group, ISO/IEC JTC 1 voted to form a Working Group focused on smart cities (Working Group 11). This vote was held in Beijing, at the 30th Meeting of ISO/IEC JTC 1 in October of 2015.[84] Every Secretary and Convenor of this Working Group since its foundation has been Chinese.[85]

This case study relates perhaps the most successful implementation of China's general approach to affecting international standards development. In other instances, China has carried out most but not all of these steps (proposing engagement on an issue, leading the ad-hoc group that scopes and proposes the formation of a new, permanent group, and eventually leading the permanent group). In this case, China managed to dominate at both the leadership and working levels, relatively unchallenged. As explored below, however, this is not always how China manages to assert influence over standardization efforts. More often, China succeeds by dominating at the working level, while ceding "competitive" positions (rapporteur-ship in key groups, or strategic leadership roles) to other nations or groups.

QUANTITATIVE DOMINANCE

One of the most common tactics that China engages in to influence standardization in areas of interest is to overwhelm to the process through a sheer quantity of Contributions. This is most evident in ITU, where each individual submission to ITU or subgroups is recorded as a "Contribution," Work Items can have an unlimited number of Supporting Members, and Work Items are not capped. Contributions, Work Items, and Members are "non-competitive" avenues for engagement – they are unlimited and non-exclusive.

A clear example of China using this tactic to its advantage is in standards related to the Internet of Things (IoT) in ITU. In sheer quantity of Contributions, China has had an outsized role in IoT standards formation. China has written a total of 403 Contributions focused on IoT since 2012 (with IoT in the title), in contrast to 2 written by the United States. A total of 951 IoT-focused contributions were written, meaning that Chinese members contributed 42% of the total IoT Contributions.[86]

China's quantitative dominance is also evident in personnel as well as submissions, primarily for less competitive leadership roles. This can be seen in Work Item patterns for almost every technology area that this report covers: Chinese members are Editors and Supporting Members on a disproportionate number of Work Items. In a system where Work Items can have uncapped numbers of Editors and Supporting Members (often having at least one Editor from each organization that serves as a Supporting Member), these roles are non-competitive, allowing for unchallenged numerical dominance. For example, In the current 2022-2024 Work Period, 67% Work

Items under review related to IoT have a Chinese Editor, Chinese Supporting Member, or (most often) both (56/83). There are 29 Questions that reference 5G in their summary; 21 of which have Chinese Supporting Members, and 20 with Chinese Editors. This trend – where China has Supporting Members and Editors for more than half of most upcoming Work Items, in contrast to one or two Work Items with U.S. representation – holds true across most of China's areas of interest.

This pattern is a logical consequence of the Chinese government's practice of financially incentivizing participation in standards organizations. Local governments sometimes offer rewards to companies who participate in standards formation, offering higher rates for working in international organizations.[87] In some cases, numbers of standards or Recommendations may appear higher because government organs encourage contributing members to split up their submissions, giving the impression of higher numbers.[88] There are maximums for these "subsidies," however, which may mean that the highest contributing organizations continue to submit contributions beyond the point where they receive additional funding.[89]

Ultimately, however, China's apparent quantitative dominance in certain international standards organizations may belie its effectiveness in influencing international standards. In a clear reflection of China's standards strategy and numbers-based reward system for its standards participants, international standards experts have complained that China's representatives have submitted large numbers of low-quality proposals that neither solve real problems nor propose real solutions and are often not technical in nature.[90] Other interviews with standards participants have suggested that although China would be well-positioned to block other nations' proposals in international standards organizations, "Chinese actors rarely block anything" and any such behavior would not necessarily "break the rules, but rather play with them cleverly."[91] Still others argue that of the myriad ways in which an entity may influence standards organizations, directly quantifiable indicators like votes, written contributions, and attendance and participation are perhaps less influential than subjective factors like being a "trusted" voice on any given committee.[92]

CHINA'S INFLUENTIAL STANDARDS

China's representatives have not only submitted a high volume of Contributions to standardization processes on topics of interest, but they have also authored many of the foundational, overarching, and strategic standards on these topics. These "foundational" standards include reference architectures, roadmaps, general specifications, and terminologies. In parallel to these influential standards, Chinese representatives often wrote key Technical Reports or other research papers that assessed the current and future development of standards on key topics. These products served as reference and guiding documents for the standardization process. These standards and research papers set the agenda for future standards development and are often among the most referenced. China's predilection for writing foundational documents indicates that China does not simply write many standards - they write *important* cross-cutting standards.

China's significant role in authoring foundational standards is evident across their technology areas of interest in ITU, even in areas where the country is not necessarily

numerically dominant. For example, China did not hold key leadership positions in the ITU Focus Group on Smart, Sustainable Cities – the early group shaping the development of smart city Recommendations – before this work was encompassed by its own study group. However, Chinese members still contributed many of that Focus Group's influential documents, such as the Technical Report examining existing standards frameworks and highlighting what China believed to be the most important standards on that topic, and the Technical Report establishing a future agenda for Smart City standardization.[93] While these documents were co-authored with non-Chinese participants, there were double the number of Chinese members participating in the drafting of these reports than there were from any other single country.[94] China followed these Technical Reports by authoring many of the foundational Recommendations for ITU's Smart City standardization framework. Fiberhome Editors drafted the only "general" Recommendation currently in effect related to smart cities, which defines "Vocabulary on Smart Cities and Communities," ("general" is a classifier established under Series Y).[95] Notably, Chinese Editors took the lead for all standards related to Key Performance Indicators (KPIs) for smart cities. Controlling the metrics by which smart cities are understood and compared gives China a significant degree of power over the expectations for smart cities, including allowing them to guide acceptable levels of security and data sharing.[96]

China's work on foundational standards in ITU was mimicked by similar work in ISO, where it is perhaps even more significant as ISO has comparatively fewer opportunities for numerical dominance. For example, China has managed to write several seminal Internet of Things (IoT) standards despite holding no formal leadership positions in relevant Working Groups. This includes a reference architecture on IoT as a whole, called "ISO/IEC 30141:2018 Internet of Things (IoT) — Reference Architecture,"[97] and several more specific reference architectures for sensor networks.[98] They also wrote a framework on interoperability, "ISO/IEC 21823-1:2019 Internet of things (IoT) — Interoperability for IoT systems — Part 1: Framework," which was published in February of 2019.[99]

These case studies are representative of the trends in ISO and ITU writ large, indicating that China's involvement in standards setting is not just high volume with low impact; China is shaping influential, agenda-setting standards.

China and the United States Compete in Battleground Issues

While China benefited from nearly unchecked influence over standards development for some of its chosen technology areas in ITU, or has competed with Korean and Japanese members for dominance in others, U.S. representatives did compete directly with China in a few, select fields. This is most visible in ITU, where observers have some degree of quantitative data assessing relative contribution levels. When China and the United States competed on issues, they tended to operate on separate, parallel tracks. In the few instances where both countries engaged in the same framework, the two appeared to adopt different strategies: the United States dominated higher-level leadership positions, while China overwhelmed with high rates of working-level participation.

China's pattern of engagement on 5G in ITU-T is a representative example. China was explicit in its view of 5G standardization as an international battlefield; according to one Chinese-language media report on China's 5G standardization efforts:

> *"5G communication has become a technological high ground for countries and regions to compete for development. Many countries are trying to have more right [sic] to speak in the field of standards, and China is leading the way to win a banner of high technology… In 5G application standards overall, China and the United States are relatively in the leading positions - and China has been involved in the formulation of 5G standards very early."*[100]

Within ITU, this competition was visible in the two parallel Focus Groups on 5G – one led by China, and one led by the United States. In ITU, the 5G standards-making process was split early on between ITU-T and ITU-R.[101] The overarching initiative was titled IMT-2020, which ITU defines as "the name used in ITU for the standards of 5G."[102] In ITU-T, a Huawei chairman and China Mobile vice-chairman led the IMT-2020 Focus Group; there were no U.S. representatives involved. In ITU-R, U.S. company AT&T led a parallel process under the Working Party 5D; no Chinese companies were involved.[103] Both groups provided research papers, approved seminal Recommendations, and held conferences – with little personnel overlap and separate working processes, despite addressing the same issues (consult Appendix 3 for detail on China's 5G engagement in ITU-T).

There was only one 5G-related topic in ITU-T where Chinese and U.S. parallel efforts came head-to-head: Question 11 in Study Group 15 in the 2017-2021 Work Period. This Question allowed for the submission of general 5G-related technology Recommendations, under the broadly defined task of "Development of relevant Recommendations related to IMT-2020/5G transport."[104] This Question was an area of disproportionate engagement from both the United States and China, with relatively few Contributions from other countries. China submitted 374 unique Contributions to this Question, marking its highest engagement on a Question over the last decade. It was also one of the top areas of engagement for the United States, with the fourth highest number of Contributions (134) it submitted over the past decade.

It is unclear which country, if any, prevailed on this Question. Nevertheless, the comparative strengths of the two parties are emblematic of the two different ways that China and the United States compete on standardization efforts. In most cases, the United States has held an upper hand in high-level leadership and strategic guidance, while China has asserted its influence by flooding the system with high rates of participation in non-exclusive areas (anywhere that has no limits on the number of submissions or participants). This case was no different; in terms of oversight and leadership, the United States appeared to outpace China. The Question had two American rapporteurs, and no Chinese assistant rapporteurs (unusual in this Work Period, where the significant majority of Questions had a Chinese rapporteur or assistant rapporteur).[105] The United States also dominated Recommendation formation with the highest number of Editors; 31 of the 70 Work Items submitted during this period had U.S. Editors, while only 14 had Chinese Editors. However, significantly more items had

Chinese Supporting Members than U.S. Supporting Members (25 vs. 12), and China still managed to take the lead on sheer number of Contributions.[106]

While the United States generally expends significantly less energy in ITU than China, it has a proven ability to gather political capital, cooperate with partners, and check undesirable standardization practices when it chooses to do so. A key example of this type of response was the coordinated rejection of Huawei's "New IP" standardization proposal at ITU-T.

Future Networks 2030 (FG-NET-2030) was an ITU-T Focus Group that was established in 2018 and concluded in 2020. The Focus Group was broadly scoped; according to its ITU webpage, FG-NET-2030:

> *"Intends to study the capabilities of networks for the year 2030 and beyond, when it is expected to support novel forward-looking scenarios, such as holographic type communications, extremely fast response in critical situations, and high-precision communication demands of emerging market verticals."*[107]

Huawei participants dominated this Focus Group; the Chairman of FG-NET-2030 was Futurewei's Richard Li, while Sub-Group 1's co-Editor was Huawei consultant Marco Carugi, and several other Huawei/Futurewei authors participated in drafting the deliverables for the Focus Group.[108] According to the White Paper that FG-NET-2030 authored as a "vision document to rationalize need for study pertaining to communications and future applications," some of the key directions for FG-NET-2030 were holographic communications, multi-sense networks, time-engineered applications, and critical infrastructure.[109]

However, the main goal of FG-NET-2030 for the Huawei participants, according to reporting from Chinese and foreign sources, was promoting the need for "New IP."[110] At the first full-group meeting of the FG-NET-2030 team, Richard Li proposed "New IP" as part of the Focus Group's agenda. "New IP" was actually a series of proposals submitted to ITU-T's Telecommunications Standardization Advisory Group (TSAG) in 2019, aimed at initiating an ITU-wide project.[111] According to Huawei, "New IP" can be understood as:

> *"...a technology study initiative, driven by a vision on scenarios for utilizing Internet technologies in many facets of the future digital industry and society. As such research initiative, it is centered on study areas that address aspects of the Internet data plane as well as its associated architecture, technologies, and protocols."*[112]

Chinese representatives presented "New IP" several times during the FG-NET-2030 proceedings, including as a proposed "solution" to many of the problems addressed in the white paper. The actual concept was developed by Huawei, in conjunction with China Mobile, China Unicom, and MIIT.[113] The term "New IP" was quickly revised in July of 2020 to "Future Vertical Communications Networks" (FVCN). Critics of the "New IP" proposal argue that ITU should wait to address this topic until IETF and IEEE (Institute of

Electrical and Electronics Engineers) have addressed them, because IETF and IEEE allow for "open, multistakeholder, and bottom-up" development rather than ITU's top-down approach.[114] They also argue that Huawei's proposal misrepresents the current state of the internet and ignores existing standardization and development projects.[115] Perhaps more importantly, IETF and other critics argue that the "New IP" proposals will jeopardize interconnectedness, undermine interoperability, and create "network islands;" in essence, dividing the internet.[116] The United States' Telecommunications Industry Association also provided a liaison statement in response to the "New IP" proposal in preparation for the 2020 World Telecommunication Standardization Assembly (WTSA) meeting, arguing that it was "contrary to the interests of the United States." This statement included a call for greater U.S. leadership within ITU-T.[117]

China's efforts to push through their "New IP" proposal were met not only with criticism from key standardization bodies like IETF but also formally halted within ITU-T Study Group 13. In December of 2020, Study Group 13 voted not to accept *any* "New IP" related work items, and also banned discussion of "New IP" through March 2022.[118]

This concerted effort to stop a proposal that was seen as particularly dangerous and detrimental indicates that the United States and partner countries have the ability to prevent China from passing specific international standards when necessary. This case study also serves as a playbook for future activities. As the ban on discussing "New IP" in ITU expires, it will be useful to track whether this suggestion resurfaces under this or another name, or whether China has pivoted its efforts to a new technology.

Involvement of Defense, Intelligence, and Sanctioned Entities

China's participation in international standards development is far from monolithic. While this report has thus far described Chinese activities at the national level, various organizations – from state-backed standardization think tanks to corporate conglomerates like Tencent and Huawei – have participated in standards work at the sub-national level. Among these more quotidian participants, however, are research institutes from China's defense-industrial base and companies that have been sanctioned by the United States either for posing a threat to U.S. national security or for violating human rights abroad.

China's defense-related participation in international standards development extends into cutting-edge emerging technologies. In the field of artificial intelligence and advanced computing, for instance, Chinese experts from the CAS Institute of Automation (中科院自动化研究所) served as project leaders for ISO/IEC 30150-31 *Information technology — Affective computing user interface (AUI) — Part 31: Emotion annotation*, [119] and the project was approved as a new work item in January 2020.[120] In February 2022, the CAS Institute of Automation also participated in the drafting of ISO/IEC 24661 *Information technology — User interfaces — Full duplex speech interaction user interface*.[121] The CAS Institute of Automation is well-known for supporting Chinese military modernization, weapons development, and adoption of artificial intelligence. It also has a track record of supporting technology development for China's domestic

security services,[122] including the Ministry of Public Security which is actively perpetrating genocide in China's Xinjiang region.

The CAS Institute of Automation is not the only notable Chinese actor participating in international standards development. In May 2019, a proposal document for AI computational approaches led by iFlytek was approved as a project under ISO/IEC, and was later published as *ISO/IEC TR 24372:2021 Information technology — Artificial intelligence (AI) — Overview of computational approaches for AI systems* in December 2021.[123] This was reportedly the first ISO/IEC AI technical report led by China.[124] iFlytek was added to the U.S. Entity List in October 2019 for materially supporting China's ongoing genocide in Xinjiang.[125]

Other notable examples indicate direct involvement in international standards by Chinese intelligence services. China served as the lead editor for ISO/IEC DIS** 23837-1 *Information technology security techniques — Security requirements, test and evaluation methods for quantum key distribution — Part 1: Requirements* and ISO/IEC DIS 23837-2 *Information technology security techniques — Security requirements, test and evaluation methods for quantum key distribution — Part 2: Evaluation and testing methods*. The Ministry of State Security – a technical component of China's domestic foreign intelligence agency – provided work which underpinned China's efforts in this area of quantum key distribution. Along with Quantumctek Co., Ltd. (科大国盾量子技术股份有限公司), and the University of Science and Technology of China (中国科学技术大学), the China Information Technology Security Evaluation Center (中国信息安全测评中心; CNITSEC) led work on formulating the standard through WG3 in 2017.[126] CNITSEC is overseen by the Ministry of State Security and is responsible for network vulnerability research.[127]

These are but a handful of examples of participation in international standards, namely in ISO and IEC. In the last half decade, Chinese defense organizations have reportedly led at least one standard for maritime navigation and another in smart manufacturing in IEC and participated in multiple ISO standards drafting efforts in space systems, nuclear power technology, and optics and photonics.[128,129] There are likely many other instances of this participation for which further details are not readily available.

The participation of defense research institutes in international standardization is likely an expression of technical prowess encouraged by China's strategy of military-civil fusion. For Chinese officials, participation in standardization work is a symbol of national prestige and a reflection of technical capability, especially for international standards. Organizations that participate in international standards are rewarded as part of local and national initiatives to accelerate military-civil fusion,[130] a strategy designed to leverage civilian science and technology innovation and advancement for military purposes, and vice versa. Official Chinese sources cite conversion or contribution of military standards

** Draft International Standard

content to national and international standards as an example of military spin-off to civilian use (军转民),[131] a critical benefit arising from China's long-running military-civil fusion efforts. In at least one instance, Chinese defense companies China Aerospace Science and Industry Corporation (CASIC) and China Electronics Technology Group Corporation (CETC) participated in the drafting of a Chinese national technical standard[132] that was then successfully converted to an ISO/IEC standard.[133]

The roles of these Chinese defense research institutes in international standardization, however, beg questions about the specific content these institutes may be advocating for in these technical standards. Many of these questions do not have readily available public answers. Like many of the above cited examples of Chinese influence, the exact effects of this participation remain obscured by a near complete lack of public detail on China's work in these international standards. These announcements of specific Chinese defense, intelligence, or entity-listed organizational participation are not made readily available on the ISO site and not in English. Our research indicates that these announcements were made only in Chinese, likely as part of the participants' desire to claim credit (and government subsidies) for leading international standards. Even when information regarding the participation of Chinese entities in international standards was successfully obtained, there was almost no information available on the exact content or nature of their participation, making it nearly impossible to characterize the quantity or quality of Chinese participation in these international standards. Nevertheless, the stated missions of these international standards participants alone warrant additional research, if not additional scrutiny.

Implications and Possible Futures for Standardization in Emerging Technologies

As discussed in this report, the "National Standardization Development Outline" and other relevant Chinese policy documents explicitly lay out China's intent to increase its engagement and influence in international standards setting bodies and dominate global standards in emerging technologies and other strategic sectors. Given this stated intent, the overall trends of increased Chinese membership and leadership positions within international standards organizations can be expected to continue. Increased submissions of proposals and contributions, both in number and frequency, will also likely remain a trend, especially as the Outline continues to incentivize participation in standards development with awards and generous state support.[134] As it devotes more state resources to improving its outcomes and increasing its influence within standards organizations, China is also expected to complement this effort by continuing to promote the adoption of its technologies and standards overseas via BRI and regional cooperation mechanisms such as BRICS (Brazil, Russia, India, China and South Africa) and APEC (Asia-Pacific Economic Cooperation).[135]

It is unclear how effective China will be at translating these strategies into global adoption of its standards and technical inputs, particularly in emerging technologies. Analysis conducted in this report as well as a review of recent studies on China's international standardization activities[136] and public comments submitted in response to NIST's Request for Information (RFI)[137] suggest that China's gains are likely to be uneven. Its increased engagement with international standards organizations is likely to result in varying levels of success depending on the particular organization and particular Subcommittee and/or Working Group being examined. Meanwhile, China's parallel effort of pursuing de facto standardization along the Belt and Road and elsewhere will likely see more consistent gains given that it has already established strong footholds in overseas developing markets for ICT infrastructure and some key emerging technology areas.[138]

Chinese Influence in International Standards-Setting is Likely to Vary by Body and Subcommittee/Working Group

In our review of recent analysis and public comments, we note that the vast majority of industry experts and other stakeholders who participate in international standards setting activities believe that the ISO and the IEC, two of the three most prominent standards-setting bodies, have sufficiently robust rules, governance systems, and safeguards in place to prevent China (or any other single actor) from exerting outsized influence in a systemic way.[139] The notable exception is the ITU-T, which industry associations and think tanks point to as the body where Chinese state influence in the standards-setting process for emerging technologies can be felt most keenly. The expansion of Huawei's membership within the body and the company's aggressive promotion of its "New IP" proposal have drawn criticism and reinforced suspicions that China seeks to promote homegrown alternatives to existing technologies. China could deploy these alternatives at best to increase its own sphere of influence and at worst to subvert and displace existing protocols.[140,141,142]

With regard to the PRC's increased engagement within ISO and IEC, industry experts acknowledge a marked increase in Chinese participation, leadership roles, and proposals/contributions submitted in key standards development organizations; however, they are generally dismissive of assessments of Chinese influence based on these metrics and instead urge for a focus on the quality, adoption rate, and market relevance of Chinese proposals.[143,144] Often cited in the public comments submitted by industry associations are two recent studies on participation and leadership within international standards organizations which both suggest that the United States and western countries still dominate these bodies despite the increase of China's membership and leadership roles within these bodies. An October 2021 Atlantic Council Geotech Center study found that the United States still dominates most international standards development organizations, holding at least 50 percent of votes in 11 of the 39 bodies the researchers surveyed.[145] The other study examined leadership appointments in a number of working groups under 3GPP, OneM2M, IETF, and IEEE. The study found that Western nationals continue to hold an outsized proportion of leadership positions, though some of the individuals included in this count represented Huawei.[146]

While these overall trends may suggest that anxiety over the rapid expansion of China's membership and leadership roles within these bodies is overblown, this report's own analysis finds that careful monitoring of subcommittees and/or working groups on critical and emerging technology areas under ISO, IEC, and ISO/IEC JTC 1 is warranted. As detailed in the previous section, China has carved out fiefdoms in key technology sectors of interest, such as smart cities development.[147] Similarly, China has made inroads in select working groups under 3GPP, a body also hailed for its strong consensus-based approach to standards setting. For instance, public comments submitted by the Alliance for Telecommunications Industry Solutions (ATIS), a 3GPP founding partner and North American Organizational Partner, note that Chinese companies are among the most active in attendance and working group voting within 3GPP's Service and Systems Aspects (SA) and SA2 working groups and its Radio Access Networks (RAN), RAN1, RAN2, and RAN3 working groups. ATIS acknowledges that while standards setting is designed to promote the best technology and innovative solutions, "a dominant presence in leadership and participation within Standards Development Organizations (SDOs) can certainly influence outcomes. We see this in China's clear intent to assume formal and informal leadership roles within 3GPP."[148]

China is Likely to Maintain Consistent Gains in De Facto Standardization

As discussed earlier in this report, China's standards export initiatives serve as a mutually reinforcing complement to its strategy of increased engagement in international standards setting bodies. Successes achieved within international standards bodies increase the chances for broad international adoption of Chinese standards, while the adoption of Chinese technologies and standards among BRI countries and elsewhere allows China to make arguments for market relevance and the maturity of its technologies when promoting the international adoption of its standards in international fora. This two-pronged approach has already yielded China success in international standards setting for critical areas like smart cities and 5G.

In the case of smart cities, China benefits from nearly a decade of experience in exporting smart cities technologies and building smart city projects overseas. A January 2020 report commissioned by the U.S.-China Economic and Security Review Commission identified 398 reported instances of smart city technology exports by Chinese companies. These exports reached 106 countries, covering developing countries as well as United States partners and allies.[149] Despite the problematic application of smart city technologies to surveillance, censorship, and control, China's experience and successes in implementing smart city projects both domestically and abroad have made it into an undeniable leader and expert on smart cities development, lending it authority when promoting smart city standards in international standards setting bodies. Within ISO/IEC JTC 1, China appears to have leveraged its status as a leader and expert in smart cities technologies into sustained and dominant leadership over WG 11 on smart cities. China not only shepherded WG 11's formation but has held every leadership role in WG 11 since its inception.[150] In a nod to the influence China wields in the group, a Chinese participant in the group was praised for her contributions to WG 11 in 2021 as her work "laid a strong foundation for China to export even more international standards for smart cities."[151]

POTENTIAL FUTURES

In assessing China's influence and impact on international standards development, especially in emerging technologies, we describe at least two possible future outcomes that may arise from this effort that can help illuminate broader implications.

CHINA ACHIEVES STANDARDS DOMINANCE IN SOME EMERGING TECHNOLOGIES

One potential outcome of China's standardization strategy is that it achieves dominance in standardization for some of its targeted critical and emerging technologies, but not all. This scenario presupposes: 1) China is able to implement the Outline and related guidance fairly effectively; 2) the United States and Europe continue to challenge China in critical technology areas; and 3) the principles of good governance and due process continue to hold in prominent consensus-based standards development organizations.

This scenario would unfold as a logical extrapolation of China's current behaviors in ISO and IEC, i.e., while it presses its advantages at every opportunity, it generally abides by agreed upon rules and norms in the standards setting process. This scenario also represents a logical extrapolation of trends and dynamics currently at play in international standards setting. It acknowledges that China has established itself as a leader in some technology areas – for instance, smart city technologies – and is consequently able to wield significant influence over international standards setting for these technologies.

In this scenario, while China's influence over international standards setting has grown, the U.S. and Europe still maintain technological superiority in other critical and emerging technologies, such as new materials, and are able to achieve and maintain dominance in international standards setting in these areas.

INCREASING BIFURCATION OF TECHNICAL STANDARDS

Another potential outcome of China's standardization strategies is the increasing bifurcation of technical standards. This scenario again presupposes: 1) that China is effective in the implementation of the Outline; 2), the United States and Europe remain formidable powers in key technology areas; and 3) the current governance model within ITU-T largely remain the same, i.e., efforts to move the body toward a consensus-based approach, if any, fail.

The tensions within ITU-T exemplified by Huawei's "New IP" proposal and China's standards export practices represent areas where bifurcation trends could easily worsen and lead to the formation of separate technological spheres. In the first case, China's growing influence in ITU-T and its aggressive lobbying for "New IP" and other proposals have raised concerns that China will use its growing influence in the body to normalize and promote other proposals with potentially severe human rights implications.[152] Although the proposal - essentially China's vision of an alternative, decentralized, and controllable internet -[153] was ultimately rejected, the episode nevertheless demonstrated China's commitment to its vision of digital governance and provided insight into the types of radical technological disruptions China is considering to ensure it eventually wields complete control over the core technologies it uses and relies upon.

While the "New IP" episode provides insight into what technological bifurcation may look like in the future, China's standards export practices along the BRI and elsewhere represent a more immediate risk for the emergence of a separate technological sphere of influence. This strategy has already enabled China to lock large swathes of the globe into Chinese standards, particularly in telecoms, rail, and energy.[154] As one example, Chinese companies dominate the telecoms market in Africa; Huawei in particular is estimated to have built approximately 70 percent of the 4G networks in Africa. Though the U.S. does strive to compete in the same regions, its efforts are vastly outmatched by the size and scale of investments and loans China has been willing to offer.[155] Assuming China continues to pursue this strategy, it is reasonable to expect that China will further cement its technological sphere of influence in the same regions as it develops and achieves prowess in some emerging technologies.

IMPLICATIONS

Some of these potential futures would have grim national security and economic implications for the United States and its allies, particularly if China's dominance of smart city technologies and standards extends to 5G, the technology widely expected to drive the "Fourth Industrial Revolution."[156] Not only would the United States stand to lose critical markets and by extension, research and development (R&D) funds crucial for fueling growth and innovation, to China, it would also need to reckon with the security risks that arise from the deployment of a Chinese controlled backbone technology in most or large parts of the world, depending on whether China is able to achieve outright dominance and win most markets. It is also important to consider the security implications of standards for critical and emerging technologies developed with inputs from PRC defense, intelligence, and sanctioned entities. As discussed in the previous section, such entities are active participants in international standards setting, and have made progress for China in key areas like AI and quantum technologies.[157] While industry experts argue

that the chances of these entities introducing security vulnerabilities intentionally during the standards setting process are low,[158] contributions to international standards made by entities explicitly identified by the U.S. government as bad actors nonetheless merit scrutiny.

MAINTAINING U.S. LEADERSHIP IN INTERNATIONAL STANDARDS ORGANIZATIONS

While views vary over the precise severity and urgency of the risk of increased Chinese influence in standards bodies, industry experts and analysts agree that the size and scale of China's ambitions – and the potential for Chinese standardization efforts to be supercharged with significant government support and resources for the next 15 years – demand immediate policy measures to ensure that the United States remains capable of maintaining sustained, robust, and effective engagement in all key international standards setting activities.[159] Failure to do so would likely lead to the U.S. ceding its leadership position in standards development organizations and cause further erosion to its technological advantages.

From an industry perspective, one current and pressing roadblock to increased U.S. participation in international standards setting is the lack of clarity surrounding the applicability of Bureau of Industry and Security (BIS) export control rules to international standards setting activities. Industry associations argue in public comments that BIS rules have inadvertently led U.S. companies to pull back from standards setting activities where entity-listed Chinese companies are also active participants, effectively ceding their place at the table as well as leadership or influence over standards in these areas.[160] Some industry associations also argue that the unclear rules – and the prospect of being excluded from influential U.S-based standards setting organizations entirely – have led China to pursue its own alternatives to existing technologies,[161] further increasing the risk of bifurcation or fragmentation of technical standards. Industry groups and companies have lobbied the Department of Commerce aggressively to clarify or make changes to BIS rules that would permit U.S. businesses and organizations to engage with entity-listed companies in all standards-setting activities. As of the writing of this report, BIS rules allow for engagement with Huawei and its subsidiaries within what critics say is a poorly defined and limited scope of standards setting activities.[162,163]

Another roadblock to increased U.S. participation in vital international standards organizations is the high cost associated with participating in standards-setting activities. Membership fees and travel costs can make the cost of participation prohibitively high for smaller companies and organizations, and the demands on time and personnel are also significant barriers. Industry associations argue that government grants or tax incentives to offset some of these high costs would encourage a wider and more diverse swathe of U.S. businesses and organizations to participate in international standards setting.[164]

These and other recommendations are discussed in further detail in the concluding section of this report.

Recommendations

Given the current state of international standards-making and its role in shaping the development and adoption of emerging technologies, the United States government should enact policies that encourage greater transparency in the international standards-making process, incentivize greater U.S. participation in international standards, and increase worldwide adoption of standards produced using preferred practices. While these objectives are sweeping in nature, if implemented successfully, the policy recommendations supporting these goals will allow the United States to compete more effectively in international standards development efforts, ensuring American economic vitality and enhancing national security.

ENCOURAGING GREATER TRANSPARENCY

First, the United States government should take action to encourage greater transparency in international standards-making for the public. International standards have considerable bearing on international trade and global economic development, yet information on processes and participants is not available to the public, which at best takes the word of international standards bodies when choosing to adopt a given standard, and at worst knows nothing of their existence. For instance, countries or businesses may adopt an international technical standard simply because of the reputational heft of the ITU while knowing nothing of a standard's provenance or the debates surrounding its origin. Specifically, the processes and work documentation for major standards bodies like ITU and ISO are not publicly available – information on standards authors and their affiliations, for instance, are not available. Additionally, there is little detailed information documenting adoption of standards around the globe, which makes it difficult to quantitatively assess the outcomes of any attempts to manipulate international standardization work.

Transparency is especially vital given China's global political, economic, and military heft and the rapid but still inchoate advancement of emerging technologies. The breakneck pace of expansion of Chinese companies into global locales can accelerate adoption of Chinese-preferred or proprietary standards in pursuit of cost savings or rapid economic development. Blind or underinformed adoption of standards governing emerging technologies could "lock-in"[165] Chinese-preferred practices, metrics, and other vital foundations for a new economy across large swaths of the globe, all without a full assessment of how the standards came to exist. The lack of transparency in international standards development processes at prominent institutions like ITU and ISO do not bode well for potentially less rigorous transparency efforts in lesser-known but equally important industry-based bodies, raising the risk that nations around the world could be unknowingly bound to Chinese-preferred standards and the attendant economic implications that result.

To improve transparency in international standards, the United States Government should:

- **Make additional funding to international standards organizations contingent upon publication of author metadata and standards uptake information.** Specifically, information on home organizational affiliation and national affiliation of standards contributors should be made public. This information would allow standards users to better assess the process by which standards are formed, without materially undermining the incentive to purchase these standards from the publishing organization.
- **Fund education efforts for participants in international standards organizations to give them more context on their foreign counterparts and the roles and missions of their respective home organizations.** The United States government should allocate resources and provide briefing information to international standards participants to better understand their counterparts. This would provide transparency for all countries but is particularly salient for Chinese organizations, as ostensibly civilian or commercial-sounding organizational monikers often obscure their explicit contributions to China's defense industry. An enhanced due diligence model would not only better inform standards participants but could also improve supply chain security efforts in emerging technologies.

INCREASING WORLDWIDE ADOPTION OF FAIR AND TRANSPARENT STANDARDS

Second, the United States government should take action to ensure that the international standards adopted by countries and companies worldwide are created through fair and transparent procedures. Having deepened transparency within standards organizations as above, the United States should focus on spreading it to large and small international standards organizations alike. Supporting and expanding institutions that are transparent and difficult to manipulate creates a level playing field for all entities to participate in standards-making, allowing the best standards to obtain broad international acceptance on their technical merits rather than through any inappropriate state instrumentality. This approach has the benefit of feasibility and effectiveness. Countering Chinese state-led standards efforts by espousing the monolithic adoption of U.S.-led technical standards around the globe would further politicize standards-making and undermine the institutional gravitas of standards organizations (and is likely impossible given the industry-led model the United States has chosen to support).

The more entities adopt and practice accepted procedures of fairness and transparency, the stickier the rules become and the harder it is for any one actor, including China, to usurp accepted practices. This is arguably already the case in major international standards organizations, where many have argued that China's deliberate efforts to impact or distort the international standards ecosystem have met with little qualitative success.[166] Nevertheless, smaller and lesser-known industry-led bodies may have fewer resources to enshrine best practices and warrant a greater effort from the United States to build stable, fair, and transparent standards-making institutions.

To increase worldwide adoption of fair and transparent standards, the United States Government should:

- **Promote further development of educational materials on best practices for international standards-making bodies.** Greater efforts from U.S. government agencies to promote fair and transparent processes in large, prestigious international standards bodies as well as lesser-known industry-led organizations would create a more level playing field for all standards participants. The principles articulated in the Office of Management and Budget Circular A-119[167] continue to hold, though the U.S. government should consider expanding the remit of its support by helping organizations that meet the spirit of the Circular but perhaps not the letter, like industry-specific organizations.[168]
- **Convene like-minded countries, companies, and other stakeholder entities to develop routine auditing processes for international standards creation.** The United States and other nations that benefit from a fair and transparent standards-making ecosystem should ensure that existing auditing processes in major international standards organizations and in smaller industry-led bodies are sufficiently robust and transparent.
- **Encourage foreign talent to come to the United States to learn and train on standards development practices.** Hosting foreign experts early and often offers unique opportunities for immersion in best practices that they are more likely to take with them to the international arena.

INCENTIVIZING GREATER U.S. STANDARDS PARTICIPATION

Third, having promoted fair and transparent practices within international standards organizations, the United States government should incentivize greater U.S. participation in these entities themselves. Should they prove successful, efforts to increase U.S. participation will materially improve the nation's future economic outlook, without resorting to active steps to exclude Chinese participation in ways that could damage beneficial existing standards-making institutions.

To incentivize greater U.S. participation in international standards-making, the United States government should:

- **Commission a research effort to understand the barriers that may be holding back U.S. participation in international standardization work**. The United States government should endeavor to identify possible barriers, like a lack of resources or a shortage of internal expertise, among industry and non-industry participants in international standards organizations. A rigorous and recurring research study would help fine-tune policy measures that could be employed to better encourage U.S. standards participation.
- **Clarify existing export control regulations that could accidentally discourage U.S. companies from participating in standards development.** Existing rules appear to create legal consequences for U.S. companies that engage in standards development work in the same venues in which Entity-Listed Chinese organizations participate. While the Bureau of Industry and Security noted that Entity List restrictions do not apply to

certain standards setting activities with Huawei, these clarifications do not apply to all types of standards development work.[169] According to the U.S.-China Business Council, some U.S. companies have reportedly been "forced to sideline themselves at some [standards setting organizations] out of a fear of legal repercussions," [170] and perhaps worse, entity-listed Chinese organizations have allegedly taken advantage by expanding their work apace in key technology areas.[171] Additional clarification of export control restrictions to make exemptions for standards development activities would again allow U.S. organizations to continue to participate in areas where Chinese entity-listed organizations are still present.[172]

- **Establish closer collaboration between the United States government and standards development organizations.** Preparation meetings between the United States government and standards organizations ahead of international standards gatherings would create a mechanism for the U.S. government to articulate any views and provide vital information to industry participants in international standards.[173]
- **Provide funding to host more international standards development meetings in the United States, including major gatherings.** Hosting meetings in the United States would likely encourage higher attendance rates from U.S. experts – a phenomenon that likely holds true for the experts of any host country, including China. Concrete ways include streamlining the foreign visa process to allow for easier travel to standards meetings inside the United States or securing a venue for hosting a meeting.
- **Provide consistent funding to sustain U.S. participation in international standards organizations.** Consistent funding streams lasting multiple years would support U.S. experts providing input in the full cycle of a standards-making process and could reduce the chances that U.S. experts would have to withdraw in the middle of a process.[174]
- **Establish funding for small businesses to participate in international standards development through tax incentives and grants.** Encouraging participation from U.S. small businesses would increase the chances that a successful technical standard contribution ultimately adopted by the international community arose from a U.S. entity, thereby accruing further economic benefits to a U.S. company. One changing the research and experimentation tax credit to include international standards setting activities as part of research and experimentation costs, for instance, would help incentivize more small business participation in international standards development work.[175]

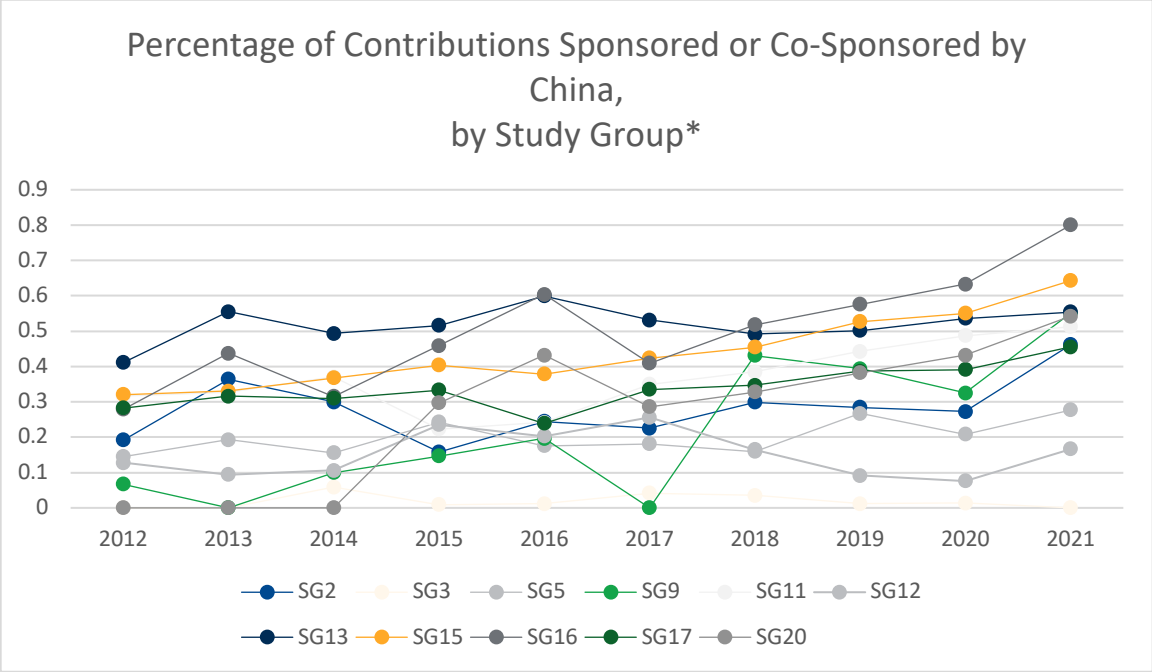
The recommendations listed in the paragraphs above are not a comprehensive roadmap to ensure U.S. success in international standards-making, nor are they meant to be punitive measures intended to reduce Chinese influence in an international institution that benefits the global economy. Instead, they are but a few of the measures that could be undertaken by the United States to improve the international standards ecosystem in ways that could enhance U.S. national security and economic competitiveness.

Appendix 1: ITU Contributions by Study Group

The proportion of contributions coming from China have, for the most part, been increasing across study groups. During the 2012-2022 study period, China made its largest percentage contribution to eight of ITU-T's 11 SGs in 2021. One of the three exceptions in the same period was SG13, in which China's 2021 contribution was its second highest after 2016. The other two SGs, SG3 and S12, appear to be the study groups of least interest to China, as discussed in more detail below.

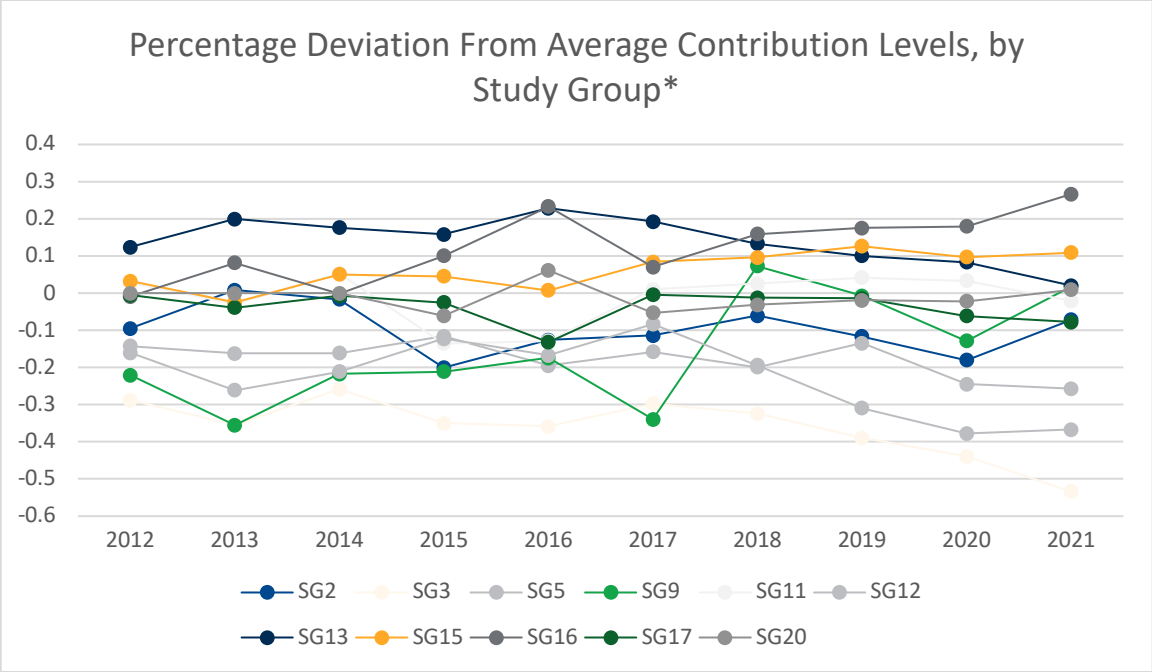
Although China's contributions to the majority of the 11 study groups increased across the board, those contributions are disproportionately distributed: three study groups garnered a large amount of attention from China, and three study groups attracted a disproportionately small amount, while the remaining five study groups received an average amount of attention.

This dynamic can be seen in the pair of figures below. Figure 8 shows the percentage of contributions made by China to each study group since 2012, while Figure 9 shows the same dynamic in a slightly different way: it visualizes how much China's proportional contribution to each study group deviates from China's average contribution level that year, represented by the 0 on the Y axis. SGs above 0 received a disproportionately greater share of contributions than average. (Note: SG20 was launched in 2015)



* - SG20 was launched in 2015

Figure 9: Percentage of Contributions Sponsored or Co-Sponsored by China, Broken Down by Study Group, 2012-22.



* - SG20 was launched in 2015

Figure 10: Percentage Deviation of China's Proportional Contributions from Average Contribution Level Broken Down by Study Group, 2012-22.

As demonstrated by the two figures above, since 2012 there have been three study groups to which China has consistently (though not always) shown more attention than the others, as evidenced by the proportion of contributions:

- SG16, which deals with multimedia technology;
- SG15, which studies optical, fiber, copper, and home networking;
- SG13, responsible for next generation networks and mobile telecommunications.
- SG 15 and 16 seem to be of special interest to China currently: in 2021, China accounted for fully 80 percent of contributions to SG16 and 64.3 percent of the contributions to SG15, the largest percentages for any group during the study period. Moreover, the proportion of submissions made by China in SG16 has increased each year since 2017. China's interest in SG13, on the other hand, seems to be dropping off, relatively speaking: since peaking at 22.9 percent above average in 2016 it has steadily fallen back toward the average, to 2 percent above average in 2021.

Then there are a cluster of three study groups for which China has consistently had disproportionate disinterest, as judged by their contribution levels:

- SG3, which studies economic and policy issues, to which China did not contribute in 2021. In the past decade, the percentage of contributions to SG3 that have been sponsored or co-sponsored by China has never broken double digits, and it has ranged from 26 to 53 percent below average.

- SG12, which deals with product quality. The percentage of contributions from China has remained at or below 25 percent during the study period, and it has ranged from 8.3 to 37.7 percent below average.
- SG5, responsible for electromagnetic fields (EMF) and environmental sustainability. This SG has been between 11 and 25 percent below average since 2012.

The remaining five study groups – SG2 (telecom and network numbering), SG9 (broadband cable and TV), SG11 (signaling), SG17 (security), and SG20 (Internet of Things) – have generally bounced around within approximately 10 percentage points of the average mark in recent years. However, SG2 has shown more significant variation (from almost exactly average, to 20 points below average) during the study period.

One important exception is that China's approach toward SG9 seems to have undergone a shift in the past five years: from 2012 to 2017 it received relatively few contributions from China, coming in at 17 to 33.9 percent below average, but since 2018 has been very close to average each year.

Appendix 2: Breakdown of Patterns in ITU Work Items

Topics of Engagement: China has written recommendations that fall into almost every study group category, engaging on 83 unique Questions. Between the study period 2017-2022, the Question that China engaged on the most – with the highest number of unique recommendations supported by a Chinese entity – was Q3 in SG20, on "IoT and SC&C (Smart Cities and Communities) architectures, protocols and QoS/QoE (Quality of Service/Quality of Experience)." Chinese entities supported 51 unique recommendations on this question. The table below lays out the top 10 questions that China engaged on between 2017 and 2022.

Table 5: The top 10 ITU Questions that China engaged on between 2017-2022.[††]

Study Group	*Question*	*Topic*	*Rapporteur Entity*	*Chinese associated entity*	*Number of Work Items*
SG20	Q3/20	IoT and SC&C architectures, protocols and QoS/QoE	Nokia	China Telecom/ CAICT	51
SG5	Q6/5	Environmental efficiency of digital technologies	Ministry of Economic Development/ European Union	CAICT	30
SG20	Q2/20	Requirements, capabilities and architectural frameworks across verticals enhanced by emerging digital technologies	Huawei	China Unicom	26
SG15	Q11/15	Signal structures, interfaces, equipment functions, protection and interworking for optical transport networks	Microsemi/Nokia	N/A	25

[††] The affiliated entity of the rapporteur for each question is laid out in column four, and if there was a Chinese "associate rapporteur" for a given question, those affiliated identities appear in column 5. Red shading indicates that the entity is Chinese.

SG15	Q14/15	Management and control of transport systems and equipment	CICT	N/A	25
SG5	Q7/5	E-waste, circular economy and sustainable supply chain management	Colegio Oficial Ingenieros de Telecomunicación (COIT)/ Ministry of Communications and Information Technology (MCIT)	CAICT	24
SG20	Q4/20	Data analytics, sharing, processing and management, including big data aspects, of IoT and SC&C	Korea	ZTE/China Telecom	21
SG13	Q6/13	Networks beyond IMT-2020: QoS mechanisms	ETRI/Wuhan Rayton Network	N/A	18
SG13	Q20/13	Networks beyond IMT-2020 and Machine Learning: Requirements and Architecture	Huawei	N/A	17
SG5	Q9/5	Climate change and assessment of digital technologies in the framework of the Sustainable Development Goals (SDGs) and the Paris Agreement	Telefon AB LM Ericsson/Orange	N/A	17

Role of Chinese Leadership in Engagement Categories: 83 percent of the Questions for which Chinese entities sponsored Work Items have a Chinese-affiliated rapporteur (affiliated with a Chinese organization or company) or associate rapporteur. 51 percent of these Questions are governed by a Chinese rapporteur, and 46 percent have a Chinese-affiliated associate rapporteur (15 percent of the Questions have both a Chinese

rapporteur *and* a Chinese associate rapporteur). This number is significantly higher than the 69 percent of total Questions that have a Chinese rapporteur, indicating that Chinese Work Items support co-occurs with leadership on a Question.

Appendix 3: Chinese Standardization Efforts in Selected Emerging Technology Areas

The section below provides a detailed accounting of China's engagement on standardizing specific technology areas of interest. This appendix is intended to serve as aggregated reference material for China's behaviors in specific sectors, supporting the top-level findings discussed in detail in Section 3.

5G COMMUNICATIONS

CHINA DOMINATES 5G STANDARDIZATION IN ITU

China has played a significant role in 5G network standardization since the introduction of this topic to ITU; its early leadership on 5G topics gave it the ability to steer development priorities. In each ITU-T Study Group focused on 5G issues, China's influence can be seen both quantitatively and qualitatively: China dominated through high rates of editorship and contributions, but also led the development of the most influential, fundamental ITU-T recommendations on 5G.

At the same time, the United States largely ceded ground to China on 5G in ITU. This section considers one example in which China and the United States competed to steer the development of one Question. Each adopted their accustomed strengths: China had outsized dominance in numbers of Contributions and Supporting members, while the U.S. governed competitive leadership rules (rapporteur-ship and editorship). The Question described below serves as a case study in the two different methods of international standardization engagement.

EARLY DEVELOPMENT

From 2017-2021, there were four main ITU-T Study Groups engaging on 5G issues: Study Group 13 (SG 13), which focused on 5G issues related to FG IMT-2020; Study Group 15, which focused on transport network standards; Study Group 5, which considered energy efficiency and 5G; and Study Group 11, which developed standards for 5G-based network protocols.[176]

SG 13

China Mobile's leadership within Study Group 13's IMT-2020 5G standardization efforts demonstrates how China's early dominance on 5G issues set the stage for continued control over 5G development efforts.

For example, in the 2017-2021 Study Period, 81 China Mobile editors were involved in authoring Recommendations for SG 13, the majority of which were focused on 5G technology.[177] While other Chinese members did participate in SG 13 work from 2017-2021, China Mobile had the largest number of editors by far, almost doubling the next highest participation rate (China Telecom, with 46 Editors).[178]

Using Contributions rather than Editor slots as a metric for dominance shows similar trends; 53 percent of Contributions to SG 13 during this time period were submitted

by China (731/1389). 184 of the Contributions were authored by China Mobile. Other contributors included companies like China Telecom, FiberHome, and Huawei; universities like the Beijing University of Posts and Telecommunications and Hubei University; and government agencies and research institutions like MIIT, CICT, and the Institute of Acoustics, Chinese Academy of Sciences (IOACAS).

SG 15

China was similarly dominant in contributing to Study Group 15 during the 2017-2021 Study Period, submitting 52 percent of the total contributions (1496/2868). Huawei and CICT each submitted more than 300 contributions to Work Items during this period. Study Group 15, tasked with "Signal structures, interfaces, equipment functions, protection and interworking for optical transport networks" standardization, focused on issues beyond just 5G, but China's Contributions were clearly targeted towards 5G-related questions.

The Question of greatest interest during this period is Study Group 15/Question 11. The main task under this Question was "Development of relevant Recommendations related to IMT-2020/5G transport."[179] This Question was an area of uncommonly high U.S. and Chinese engagement, with relatively few Contributions from other countries. This Question is a staging ground for conflicting standards-setting agendas, as one of the few areas where China and the U.S. both contribute extensively.

This was the top Question that China contributed to over the last decade, at 374 unique Contributions, which is more than double the number of contributions submitted by China compared to the Question with the next highest volume of contributions. It was also one of the top areas of engagement for U.S. members, who submitted 134 Contributions (the fourth highest Question by contribution numbers).

Table 6: Top U.S. and Chinese contributors to Question 11/15 (Study Period 2017-2020. Only contributors who submitted at least 10 Contributions are shown.

Contribution Source	Number of Contributions
China Information Communication Technologies Group	127
Huawei Technologies Co., Ltd. (China)	78
Nokia USA (United States)	60
ZTE Corporation (China)	44
China Mobile Communications Corporation	42
Microsemi Corporation (United States)	22
China Telecommunications Corporation	21
Huawei Technologies Düsseldorf GmbH	21
FiberHome Technologies Group (China)	15
China Mobile Communications Co. Ltd.	11
Microchip Technology Inc. (United States)	11
Acacia Communications, Inc (United States)	10
Broadcom Corporation (United States)	10
Intel Corporation (United States)	10

Question 11/15 can serve as a case study for how Chinese and U.S. standards interests are translated into Recommendations when the two countries engage on the same issue. Interestingly, this Question had two U.S. rapporteurs – an outlier, because most questions during this study period had at least one Chinese rapporteur or assistant rapporteur.[180] This suggests that the U.S. had the upper hand in dictating the scope and direction of Recommendation formation under this Question. Bolstering this assumption is the predominance of U.S. Editors for the 70 Work Items submitted during this period – 31 of the Work Items had U.S. Editors, while only 14 had Chinese Editors. However, significantly more items had Chinese Supporting Members than U.S. Supporting Members (25 vs. 12). Cumulatively, these discrepancies between contribution rates and personnel in leadership indicate that this Question was an area where China and the U.S. struggled for dominance.

Table 7: Representation of U.S. and Chinese Rapporteurs, Work Item Editors, Work Item Supporting Members, and Contributions to Work Items for Question 11/15

	United States	China
Rapporteurs	X	
Work Item Editors	X	
Work Item Supporting Members		X
Contributions to Work Items		X

SG 5

China's engagement in ITU-T 5G technology standardization extends to Study Group 5, which focuses on environmental consequences of 5G networks.

China's success in Study Group 5's 5G work appears to be more limited than in other Study Groups. While China did submit 47 percent of the 5G related Contributions to Work Items in this Study Group (24/51), China was not overseeing or supporting most of the Work Items that were actually approved. Of the 17 Work Items related to 5G that were "approved" or "agreed to" during this period, only four had a Chinese Editor, and in only one case were all the Editors and Supporting Members Chinese.[181]

SG 11

China was perhaps most successful in guiding Study Group 11's 5G Contributions during this study period. There were six approved Recommendations related to 5G in 2017, all flagged as pivotal 5G projects in ITU's report on 5G standardization in the 2017-2021 Work Period. Every single Editor related to any of the Work Items was Chinese. This suggests China was the only influential voice on 5G network protocols, Study Group 11's focus, until this point.[182]

This level of influence continued into the Work Items marked as "in progress" during this period; of the eight ongoing Work Items noted in the ITU 5G standardization report, six of the Work Items had Chinese (and only Chinese) Editors and Supporting Members.[183] All but one of the Work Items that were overseen by Chinese Editors during

this period were approved, indicating that Chinese members successfully guided early standardization of 5G protocols. Only one non-Chinese 5G standard in Study Group 11 during this period was ever approved.[184]

UPCOMING WORK ITEMS

In the current 2022-2024 Work Plan, there are 29 Questions that reference 5G in their summary. Of these 29 Questions, there are Chinese Supporting Members for 21, and Chinese Editors for 20. Moreover, 18 of these Questions have *only* Chinese Editors, indicating that China has significant power to dominate the conversations on 5G standardization. In comparison, there is only one U.S. company or individual represented on 5G standardization issues (AT&T).

A significant number of the Questions that Chinese members lead focus on 5G security, indicating that China is shaping international standards for networking security. Of particular interest is the "Requirements and framework of AI-based detection technologies for 5G multimedia messages" Work Item, which has been covered by Chinese media since earlier draft stages in 2021. According to Chinese reporting, this draft was led by China Mobile (who is not listed as a supporting member in the current Work Plan), and based on China Mobile's experience building an AI-detection system for 5G messages. The system, a 5G message content security management and control platform developed by China Mobile Hangzhou Research Institute, was rolled out in January 2021, and adopted by almost a hundred million users by April 2021.[185] This Work Item is still under consideration.

5G COMMUNICATIONS IN ISO

ISO does not engage significantly in 5G standardization efforts; this area is dominated by 3GPP and ITU-T.[186] ISO explicitly recognizes ITU as the main standards body for 5G in a recent publication on "Connectivity."[187] Crucially, ISO points to IMT-2020 as the main ITU group focused on 5G standardization; IMT-2020 was a Huawei-led Focus Group with a vice-chair from China Mobile and no U.S. representation.[188] While IMT-2020 is no longer active,[189] ISO's acknowledgement of that body as a primary reference for 5G standards indicates that the China-run group has significant power over ISO's perception of 5G standardization.

ISO is currently working on a single 5G-related standard, "Sustainable mobility and transportation — Framework for transportation services by providing meshes for 5G communication."[190] No information on Editors or key governing bodies is provided for this standard.

SMART CITIES

China took two alternative paths to dominating smart city standardization in ITU and ISO. In ITU, China dominated the authorship of foundational Recommendations and success metric Recommendations but did not hold an outsize proportion of leadership positions. In ISO, China held every relevant leadership role in evolving body responsible for overseeing smart city development, while passing some, but not all, of the most foundational standards.

SMART CITIES IN ITU

China has been the dominant standardizing voice on smart cities in ITU-T since the topic was first addressed. In this case, China's dominance is rooted not in high-level leadership, but in steering the most foundational and fundamental Recommendations: the terminology and architecture standards.

EARLY DEVELOPMENT

Smart cities in ITU-T are currently overseen by Study Group 20, which focuses on "Internet of Things, Smart Cities and Communities." However, this Study Group was not approved until 2015, and was officially formed in 2016.[191] Predating the formation of Study Group 20, a Focus Group was created to address the issues related to "Smart Sustainable Cities."[192] This Focus Group was established in February 2013 and was terminated after the proposal to establish a Study Group was approved in 2015.

China participated in this Focus Group, but neither led the group nor numerically dominated the participant roster.[193]

However, representatives from Fiberhome authored some of the most influential reports within that Focus Group, including the Technical Report on "Standardization activities for smart sustainable cities," which provided an outlook on the current standardization related to smart cities and identified a future agenda, and the Technical Report on "Standardization roadmap for smart sustainable cities," which established the future agenda.[194] Fiberhome personnel also dominated the authorship of the Technical Report on "Key performance indicators definitions for smart sustainable cities," with four out of the 16 authors coming from Fiberhome (no other company had more than two).[195] These Technical Reports laid out a path for the future of Smart City development.

RECOMMENDATIONS

China's robust participation in the Focus Group transitioned to dominance in key Recommendation formation in the Study Group; China grew to lead to the terminology, overview, and agenda-setting Recommendations, often with the same personnel from the Focus Group. Chinese authors from Fiberhome served as Editors for the "Vocabulary on Smart Cities and Communities" Recommendation.[196] This is the only "General" Recommendation for smart cities under Study Group 20 ("general" is a classifier of Recommendations under the Y series).[197]

Notably, Chinese Editors took the lead for all standards related to Key Performance Indicators (KPIs) for smart cities. Controlling the metrics by which smart cities are understood and compared gives China a significant degree of power over the expectations for smart cities, including allowing them to guide acceptable levels of security and data sharing. The first three standards setting KPIs in 2016 were written exclusively by Fiberhome's Ziqin Sang. A following set of KPIs addressing sustainability and maturity of smart cities, mostly approved in 2019, were written by Ziqin Sang along with the UAE's Okan Geray. This second set included involvement beyond Chinese entities, but that involvement extended only to other non-democratic countries (UAE, Saudi Arabia, and Malaysia).[198]

China took special interest in forming Recommendations related to a "Smart City Platform" (SCP). The key Recommendation on SCP is the "High-level requirements and reference framework of smart city platform," which is written by four Chinese Editors and one Indian Editor. The SCP is defined as "a city platform that offers direct integration of city platforms and systems, or through open interfaces between city platforms and third parties, in order to offer urban operation and services supporting the functioning of city services, as well as efficiency, performance, security and scalability." This Recommendation proposes a broad-sweeping system for organizing security, data collection, communication, maintenance, and public information dissemination tasks.[199]

UPCOMING WORK ITEMS

In the current 2022-2024 Work Period, there are 32 issues that specifically address smart cities, the majority of which fall under Study Group 20. Of these issues, 18 have Chinese Editors; an additional one has a Chinese Supporting Member. This level of engagement, while still high, actually represents a diversification of countries involved in Smart City standardization at ITU. Countries other than China are developing guidelines for SCPs, interoperability, data sharing, and cybersecurity – areas that were previously dominated by China. Notably, many Recommendations, edited by different companies and countries, appear to be engaging on the same issues. Measuring China's success at steering smart city standards in ITU may require considering whether certain Recommendations get passed, while others are discontinued or absorbed, or considering the effects of parallel and mutually exclusive Recommendations.

SMART CITIES IN ISO

China's efforts to push international standards on smart cities in ITU were mirrored by similar efforts in ISO; China led a Study Group and then a Working Group on smart cities in ISO.

EARLY DEVELOPMENT

China recommended the formation of a Smart City Study Group, led said Study Group, and then proceeded to hold every leadership role in the ISO body for smart cities from its formation until the present.

China recommended the establishment of a Study Group to research smart cities in early 2013, with a proposal called "China Contribution on Possible Future Work on Smart Cities in JTC 1."[200] This proposal was accepted and led to the formation of the Study Group on Smart Cities at the 28th ISO/IEC JTC 1 plenary meeting in France in November of 2013.[201] Yuan Yuan of CESI was appointed as the convenor, and Liu Tangli (also from CESI) was appointed as the secretary for the SG.[202,203]

Two years after the formation of the Study Group, ISO/IEC JTC 1 voted to form a Working Group focused on smart cities (Working Group 11). This vote was actually held in Beijing, at the 30th Meeting of ISO/IEC JTC 1 in October of 2015.[204]

Since the formation of this Working Group, every officer (every Secretary and Convenor) has been Chinese:[205]

Table 8: Chinese Secretary and Convenor Names for WG 11 Since Formation in 2015

Role	Officer	Country	Tenure
WG 11 Convenor	Yuan Yuan	China	October 2015 – October 2016
WG 11 Convenor	Heng Qian	China	November 2016 – December 2022
WG 11 Secretary	Tangli Liu	China	October 2015 – June 2020
WG 11 Secretary	Ning Sun	China	July 2020 -September 2020
WG 11 Secretary	Hongwei Zhang	China	September 2020 –

There are three Task Forces that fall under the purview of this Working Group: the "Task Force (TF) on Urban Operation System," the "Task Force (TF) on the Pilot Implementation Programmes and Use Cases Study," and the "Task Force (TF) on Data Use in Smart City." The latter two of these Task Forces both have Chinese convenors.[206]

STANDARDS

Because ISO does not provide authorship data on its standards, nor does it make standards publicly available in bulk, China's influence on smart city standards in ISO can only be evaluated from an anecdotal lens. Chinese media reports and announcements from Chinese companies suggest that China led or drafted several highly influential ISO standards on smart cities.

CESI claims that, in August of 2020, six of the ten international standards released by WG11 were "transformed based off of Chinese national standards or practical experience."[207] Several of the smart city standards were based on Chinese domestic standards.[208,209]

China's personnel leadership in WG11 had significant impacts on its influence over the standardization process. For example, in 2021, Renmin University's An Xiaomi was recognized as the individual with the year's most outstanding achievements by WG11. The list of her accomplishments illustrates the extent of Chinese influence over this process: she was praised for her work in "successfully laying a foundation for my country to export more international standards about smart cities" (为我国输出更多智慧城市国际标准成果奠定了重要基础). Her work included supporting PhD students in developing proposals for ISO standards and submitting them to WG11. She also created and then convened WG11's Task Force on "Data Use in Smart City."[210] The case of An Xiaomi illustrates how China leverages leadership positions to promote a national standards agenda.

THE INTERNET OF THINGS (IOT)

IOT IN ITU

China led early IoT standardization efforts in ITU, holding leadership roles and writing Recommendations for terminology. Since the establishment of Study Group 20 in 2017, China's IoT Recommendations have become more specific to use cases; China now focuses energy on "Smart Ocean" and "Smart Manufacturing" Recommendations, both of which have strategic importance.

EARLY DEVELOPMENT

ITU-T has been writing standards addressing IoT since the early 2000s; in 2005, ITU released a 130-page report on the Internet of Things for the World Summit on the Information Society held in Tunis from November 16 to 18.[211] However, ITU's first concerted standardization effort for IoT was the Internet of Things Global Standards Initiative (IoT-GSI). IoT-GSI was an umbrella organization that "aimed to promote a unified approach in ITU-T for development of technical standards (Recommendations) enabling the Internet of Things on a global scale… IoT-GSI also aimed to act as an umbrella for IoT standards development worldwide." ITU-T's IoT-related Recommendations developed under the purview of IoT-GSI, regardless of their Study Group or Question. Like the Focus Group on Smart, Sustainable Cities discussed above, IoT-GSI was disbanded in 2015 when Study Group 20 was established to take over this sector.[212]

China appears to have led this first coordinated IoT standardization effort in ITU. MIIT's Heyuan Xu was the Technical and Strategic Review (TSR) Coordinator for IoT-GSI from 2012 to 2015 (when the group was disbanded). He was responsible for overseeing the work of the group.[213] The TSR Coordinator is the top role in a GSI; his role is to develop a workplan, coordinate with relevant Questions, and organize the event.[214]

RECOMMENDATIONS

In sheer quantity of Contributions, China has had an outsize role in IoT standards formation. China wrote a total of 403 Contributions focused on IoT since 2012 (with IoT in the title), in contrast to two written by the United States. Since 2012, there have been a total of 951 written, meaning that Chinese members wrote 42 percent of the total IoT Contributions.[215]

ITU began publishing IoT related standards almost a decade before the establishment of Study Group 20, and developed some of the most foundational Recommendations on this topic. These early standards defined the terminology and metrics used to evaluate IoT technologies. For example, Haihua Li was the Editor for "Terms and definitions for Internet of Things," and a co-Editor with a Korean counterpart on the "Overview of Internet of Things."[216] Both of these Recommendations were approved in 2012.[217] Li is the Vice Chief Engineer of Institute of Communication Standards Research of the Chinese Academy of Telecommunications Research (CATR), MIIT, and one of the most active Chinese voices on IoT standardization, both within domestic and international standards contexts.[218]

China has more recently taken an active stance in steering standards in what it views as the most pivotal subfields of IoT. This includes the development of a Recommendation for "Smart Oceans and Seas," led by Chinese members not only from telecommunications companies, government agencies like MIIT and CAICT, but also from CETC Information Science Academy. CETC was one of various Chinese military-industrial complex companies to be sanctioned by the United States in 2021.[219] According to Chinese reporting on the development of the Recommendation, the process was led by MIIT and the research branch of China Shipbuilding Industry Corporation (CSIC),

another PRC military-affiliated company sanctioned by the United States.[220] CSIC and Fiberhome had both been developing "Smart Ocean" technology for years leading up to the passage of these standards, focused on "undertaking the tasks of the national marine power strategy." Communication (submarine optical cable networks) and marine monitoring were some of the focuses of Chinese "Smart Ocean" development.[221‡‡]

China also wrote Recommendations centered on "Smart Manufacturing" or "Industrial IoT," which was established as a strategic priority by CAICT. Haihua Li, who was one of China's main representatives on IoT standards and authored early IoT Recommendations at ITU, gave a presentation on "Standardization for Industrial IoT" sometime in 2015. The presentation focused on China's plan for "Smart Manufacturing" standards, including a timeline for proposed standards releases.[222] The ITU Recommendation on "Smart Manufacturing," called "Overview of smart manufacturing in the context of the industrial Internet of things," was written solely by Chinese members.[223]

UPCOMING WORK ITEMS

In the current 2022 to 2024 Work Period, 67 percent of Work Items under review have a Chinese Editor, Chinese Supporting Member, or (most often) both (56/83). These items range thematically from sustainability and environmental focused Recommendations, to security protocols, reference architectures, firefighting and emergency response IoT architectures, traffic-related IoT, and blockchain. China took a special interest in blockchain for IoT, with 10 unique Work Items focused on using blockchain technologies for IoT data management. Few democratic countries or members from democratic countries are competing to lead Recommendations in the IoT space.

IOT IN ISO

China does not hold leadership roles in the ISO organizations focused in IoT, and has not historically. However, Chinese organizations still led the development of many foundational IoT standards, including on terminology and reference architectures.

EARLY DEVELOPMENT

The current entity responsible for coordinating IoT-related work under ISO is ISO/IEC JTC 1/SC41, which was founded in 2016. This group was intended to incorporate

‡‡ China has established "marine standardization" (海洋标准) on both domestic and international levels as a high strategic priority. Xi Jinping has formally established "national marine power" as a crucial part of "Socialism with Chinese Characteristics," while standardization in this area is key for the "four large transformations" (四大转变) China needs to make in this area. A 2021 article published by the Chinese Academy of Sciences (CAS) and presented at the National Standardization Forum assessed China's progress and upcoming strategy for marine standardization. Between 2015 and 2021, approximately 200 domestic maritime standards were proposed annually. Between 2018 and 2020, under the "Marine Standards System" (海洋标准系统), more than 695 standards and revisions to existing standards were proposed, and 293 were approved. Greater national cohesion on marine standards was combined with a push for greater influence on international marine standards; the Chinese strategy on marine standardization specifically calls for using the "Belt and Road" initiative as a tool for promoting the "Chinese voice, Chinese wisdom, and Chinese solutions" in international marine standards.

projects from JTC 1/WG 7 (Sensor Networks, which was created in 2010), and JTC 1/WG 10 (IoT, which was created in 2014).[224] China made significant headway in standards setting under both of these Working Groups, despite the fact that both were led by Korean secretariats (see below for more detail).[225]

ISO/IEC JTC 1's Subcommittee 41 (SC41) focuses on the "Internet of Things and Digital Twin." SC41 is administratively supported by IEC. There are no Chinese officers of this Study Group (the Secretariat and most of the officers are Korean; the current Chair is Canadian. Similarly, very few of the Working Group and Advisory Group convenors are Chinese; there are Chinese convenors for W6, the Digital Twin Working Group, and W4, which focuses on IoT Interoperability.[226]

STANDARDS

Despite the fact that China currently does not hold significant leadership roles within SC41, China has historically pushed through several significant standards related to IoT that fall under this group.

Under WG7, China was responsible for developing or editing several parts of a series of IoT-related standards focused on Sensor Networks. Three of the parts of this series were either developed by Chinese entities, or had a Chinese Lead Editor. There were 11 standards in total.[227] In June of 2013, "ISO/IEC 29182-2:2013 Information technology — Sensor networks: Sensor Network Reference Architecture (SNRA) — Part 2: Vocabulary and Terminology" was published. A Chinese expert was appointed the project's lead editor.[228] In July, "ISO/IEC 20005:2013 Information technology — Sensor networks — Services and interfaces supporting collaborative information processing in intelligent sensor networks" was published. This project also had a Chinese Lead Editor.[229] Finally, in August, "ISO/IEC 29182-5:2013 Information technology — Sensor networks: Sensor Network Reference Architecture (SNRA) — Part 5: Interface definitions" was published.[230] The standard was developed by Wuxi Sensing Net Industrialization Research Institute (无锡物联网产业研究院), Chongqing University of Posts and Telecommunications (重庆邮电大学), and CESI.[231] China published a follow-on standard on sensor networks a few years later. "ISO/IEC 19637:2016 Information technology — Sensor network testing framework" was not published until December of 2016 (after the establishment of SC41), but the project was approved in October 2014, and a committee draft was registered in October 2015.[232] The project was proposed jointly by CESI and Chongqing University of Posts and Telecommunications (重庆邮电大学).[233]

Two of the most apparently influential standards that China authored related to IoT were passed under WG10. These standards appear particularly influential because they set broad terminologies and frameworks for IoT development overall. Only four standards were published under this Working Group; two of them were written by China.[234] The first was "ISO/IEC 30141:2018 Internet of Things (IoT) — Reference Architecture," which was published in August 2018, but was approved as a project in October 2014 and registered in the TC/SC work program in May 2015.[235] The proposal was submitted by CESI and Wuxi Sensing Net Industrialization Research Institute (无锡物联网产业研究院) in September 2013.[236] The second was "ISO/IEC 21823-1:2019 Internet of things (IoT) — Interoperability for IoT systems — Part 1: Framework," which was published in February

of 2019. It was approved as a project in July 2016, and a committee draft was approved for registration as DIS in September 2018.[237] Development of the standard was led by Chongqing University of Posts and Telecommunications (重庆邮电大学) and CESI.[238]

UPCOMING WORK ITEMS

Only five of the 25 items in the current Work Program for SC41 have Chinese project leaders. Four of the five are focused on Digital Twins, suggesting that there is a significant relationship between project leadership and convenorship (Digital Twin is one of the two Working Groups overseen by a Chinese member). The fifth is focusing on designing requirements for ecological environmental monitoring.[239]

QUANTUM INFORMATION SCIENCES

QUANTUM INFORMATION IN ITU

Quantum information sciences appears to be one of the few areas where Chinese engagement has been met and challenged by U.S. and U.S. partner nation efforts. This is evident across various metrics for participation in standards formation. China and U.S. partner countries both engage actively in quantum-related Contributions, Focus Groups, and Recommendations.

CONTRIBUTIONS

The first Contributions related to quantum in ITU-T appeared in 2016, but a distinct effort to standardize quantum, with a high frequency of Contributions, did not emerge until 2019.

There are 179 Contributions that name quantum in their summary. Of these, only 48 were submitted by China; this is a relatively low Contribution rate for China (27 percent). While American and European countries submitted Contributions much more sparingly to this issue (lower frequency of Contributions appears standard across most issues for these countries), Japan and Korea submitted a similar number of Contributions to China.[240]

EARLY DEVELOPMENT

ITU-T established a Focus Group on Quantum Information Technology for Networks (FG-QIT4N) in September of 2019, correlating with the sharp upswing in quantum-related Contributions. This Focus Group is chaired by representatives from Russia's Rostelecom, China's University of Science and Technology, and the U.S.' L3Harris. There are two additional Chinese vice-Chairs. One of the Working Groups is chaired by a German representative, and the other by a Chinese representative. Across the board, the leadership is split between democratic and non-democratic countries.[241]

Despite the fact that China did not dominate this Focus Group in terms of numbers, they appear to have dominated the work that the group produced. Chinese members served as Editors on every single deliverable produced by the Focus Group. Several of the Technical Reports were solely authored by Chinese representatives; for example, a representative from CAS Quantum Network wrote the Technical Report on "Quantum

information technology for networks terminology: Network aspects of quantum information technologies."[242] This indicates that China had a dominant role in establishing the language and technical definitions ITU-T uses for quantum. In several cases, one Chinese and one U.S. author co-Edited the Technical Reports, illustrating the power sharing on quantum-related standards. These Technical Reports include one setting the terminology for Quantum Key Distribution Networks (QKDNs) "Quantum information technology for networks terminology: Quantum key distribution network," and the Technical Report that served as a roadmap for future quantum standardization, "Standardization outlook and technology maturity: Network aspects of quantum information technologies."[243]

RECOMMENDATIONS

While China has not been the sole voice contributing in ITU-T quantum standards setting, they have guided the formation of some specific quantum-related standards. For example, China contributed 50 percent (5/10) of the Contributions related to the formation of "X.1811," which was originally named "Security guidelines for applying quantum-safe algorithms in 5G systems,"[244] and became "Security guidelines for applying quantum-safe algorithms in IMT-2020 systems."[245] Moreover, the Work Item was overseen by four Chinese contacts, underscoring Chinese involvement in the Recommendation.[246] This Recommendation, approved on April 30, 2021, focused on designing algorithms that addressed the risks posed by quantum computing to traditional symmetric and asymmetric cryptographic algorithms.

One quantum-related technology that China has been focused on is Quantum Key Distribution (QKD) security. The first ITU standard published on QKD was written by the Quantum Alliance Initiative (QAI), and includes the U.S. and allied countries, like Canada, England, Australia, Japan, and South Korea. China was not included. There were 18 company participants from eight countries as of January 2019, when the first QKD standard was approved. According to Chinese media reporting on that event:

> *"Consistently prioritizing U.S. quantum leadership, the coalition's mission is to shape global policy, and guide and create a robust quantum ecosystem in which the U.S. and its allies are the global leaders in quantum technology, while ensuring that the United States can resist quantum computer cyberattacks and gain the maximum benefit." (该联盟始终将美国的量子领域领导地位摆在首位，其使命是制定全球政策，指导并创建一个强大的量子生态系统，并保证其中处于量子技术全球领导者的则是美国及其盟国，同时确保美国能够抵抗量子计算机网络攻击并获得最大利益)."*[247]

The group was designed in opposition to China's efforts in quantum computing, according to its prospectus. The Hudson Institute, which proposed and formed the group, cited China's decade-long pattern of stealing encrypted data with the intention to break the encryption using future quantum computers as an impetus for the U.S. to develop a stronger quantum alliance. According to the QAI's founders: "For China, winning the quantum race and protecting its own networks from quantum attack and penetration are both essential parts of a high-tech supremacy strategy."[248]

China's first domestic standards on QKD were not published until January of 2021, indicating that China was slow to develop a foothold in this area of standardization, despite the National Standardization Development Outline's specific mention of quantum as a priority area for Chinese engagement.[249] In October of 2021, MIIT made a clear recommitment to quantum standardization, saying that they will "promote quantum standardization research in international standardization organizations such as ISO and ITU."[250]

Of the 125 Contributions submitted to ITU-T on QKD, 34 were written by Chinese members, including CAS Quantum Network Co. Ltd. (10 Contributions), Beijing University of Posts and Telecommunications (17 Contributions), Huawei Technologies Co., Ltd (1), China Unicom (3), China Telecommunications Corporation (1), and QuantumCTek Co., Ltd. (3 Contributions) (one Contribution was co-authored). However, there is a measurable spike in Contributions related to QKD in the wake of the October 2021 MIIT statement on quantum standardization, with ten new Contributions submitted in November.[251]

UPCOMING WORK ITEMS

In the current 2022-2024 ITU Work Plan, China has established a clear foothold to steering future QKD standards. There are 20 Work Items intended to address QKD in this period (see table below). All but four of these Work Items have at least one Chinese Editor. Three have exclusively Chinese Supporting Members and Editors. Most of the participants in QKD standards processes are Chinese or South Korean, with some Japanese participants. Only two standards have any representation from Europe, Australia, or North America; none have U.S. representatives.

QUANTUM IN ISO

Quantum standardization at ISO is still in its early development phases, but China holds both the top leadership roles on this issue and is writing one of the upcoming quantum-related standards (which it has championed since its introduction).

WORKING GROUPS AND SUBCOMMITTEES

In June of 2020, ISO/IEC JTC 1 established WG 14, which is dedicated to Quantum Computing. This WG was originally from SG2 and AG4 (Advisory Group 4). WG 14's officers (secretary and convenor) are both Chinese. All the meetings held so far have been virtual. While WG 14 is responsible for organizing JTC 1's quantum-related work, most of the standards fall under different subcommittees.[252]

There are three different subcommittees under ISO/IEC JTC 1 that perform research on quantum technologies. This includes JTC 1/SC 7 (which has a study group focused on investigating the Quantum Computing standards related with software engineering), JTC 1/SC 27 (Quantum Key Distribution), and JTC 1/SC 38 (Quantum Computing cloud service).[253]

In 2018, China made a concerted effort to push quantum standards in JTC 1/SC 27. According to a 2018 presentation from Hongsong Shi from the China Information Technology Security Evaluation Center, and Jiajun Ma from QuantumCTek, China aimed

to supplement ITU-T SG 17 QKD standards (most of which they wrote), as well as IEEE P1913 QKD standards. China argued that current standards were not "appropriate in guiding QKD security evaluation," necessitating the development of further standards under ISO.[254]

Upcoming Work Items

The standard that China proposed in 2018 is currently in the DIS voting/comment phase under the name "ISO/IEC DIS 23837-2 *Information technology security techniques — Security requirements, test and evaluation methods for quantum key distribution — Part 2: Evaluation and testing methods*."[255] China is the Lead Editor for the standard; the UK, Singapore, and Luxembourg are co-Editors. China Information Technology Security Evaluation Center (中国信息安全测评中心), Quantumctek Co., Ltd. (科大国盾量子技术股份有限公司), and University of Science and Technology of China (中国科学技术大学) led work on formulating the standard through WG3 in 2017.[256,257]

Big Data

Big Data in ITU

Big Data standardization in ITU is disjointed, but China was responsible for many of Big Data foundational standards. As Big Data standardization continues, China is engaging on specific Big Data use cases.

Early Development

Quantitatively, China appears to have engaged frequently on Big Data questions, submitting 119 Contributions mentioning Big Data in their title out of the 192 submitted to ITU total.[258] China was also involved in most of the earliest standards mentioning "Big Data." Of the 12 Work Items related to Big Data from 2013 to 2016, all but three had Chinese Editors.[259] Most of these were carried to the next Work Period, but one foundational Recommendation, and perhaps even its more influential supplement, was approved; the Recommendation was "Big data – cloud computing based requirements and capabilities," which focused on how to use cloud computing to handle large amounts of data, while the supplement was the "Big Data Standardization Roadmap," laying out the plan for future Big Data Recommendations.[260] The original Recommendation had a Chinese co-Editor, while the roadmap was written by a single, Korean author.[261]

Chinese Editors and Supporting Members were involved in 31 of the 48 Work Items related to Big Data in the 2017 to 2020 Work Period.[262] China participated in all manner of Big Data-related Recommendation formation, focused on issues like IoT and Big Data, security guidelines for Big Data platforms, and Big Data Driven Networking (BDDN).[263] Chinese news media reported on the passage of several of these international standards. For example, one article highlighted the acceptance of two Chinese-led data management Recommendations, published under Study Group 16 in 2018. According to reporting, these Recommendations were derived from domestic standards, formulated under the guidance of the Data Center Alliance (数据中心联盟) and the China Communications Standards Association.[264] Another focused on China Telecom's leadership of Telecommunications Management Network (TMN)-related Big Data

proposals for Study Group 2 in 2017, highlighting that "these two project won the support of many countries' representatives; they were smoothly approved."[265]

UPCOMING WORK ITEMS

In the 2022-2024 Work Period, 10 of the 21 Work Items related to Big Data have Chinese Editors or Supporting Members. China is involved in both Recommendations focused on Big Data Driven Networking. China is also involved in fraud detection and security systems focused on Big Data.[266]

BIG DATA IN ISO

As in ITU, the approach to Big Data undertaken in ISO is fragmentary. Various subcommittees, including ones on Artificial Intelligence, Data Management and Interchange, and "Information security, cybersecurity and privacy protection," all addressed different aspects of "Big Data."

According to ISO publications, China was the force behind many of the most important Big Data standards. This section identifies China's role in the two Big Data standards series.

EARLY DEVELOPMENT

In 2014, ISO/IEC JTC 1 established a Working Group specifically geared towards Big Data (WG 9, Big Data). The Working Group reported directly to JTC 1. This Working Group was disbanded in 2017, and Big Data was incorporated into the scope of SC 42 (Artificial Intelligence); the Work Programme, including a Big Data Reference Architecture series, was transferred to that subcommittee.[267] The previous convenor of WG 9, Wo Chang (of NIST), is now the convenor of SC 42/WG 2 ("Data").[268]

STANDARDS

According to a white paper released by CESI, China was the lead author on the deliverables that fell under WG 9. In that role, China led the development of "ISO/IEC 20546:2019 Information technology — Big data — Overview and vocabulary."[269] The project was approved in October 2015, and a committee draft was registered in April 2016.[270] Huawei Technologies (华为技术有限公司) led the project.[271] The project was eventually approved in February of 2019, after the work was transferred under SC 42.[272]

China led another series of Big Data standards that began under WG 9 and were eventually moved under a different subcommittee. The "Big Data Reference Architecture" (BDRA) series was a five-part series, also called the "20547 series." The majority of these standards were moved under SC 42 in 2017; the fourth part of the series, however, is under SC 27, WG4/5.[273] This fourth part, "ISO/IEC 20547-4:2020 Information technology — Big data reference architecture — Part 4: Security and privacy," was led by Chinese experts. It was approved in September of 2020.[274]

China's leadership on the 20546 and 20547 series standards is significant; ISO commentary touts these as a "comprehensive range of standards and technical reports" intended "[t]o clear up any confusion and provide a stable base to address the challenges and opportunities of big data."[275]

According to CESI's white paper, China also considers several deliverables that it led under SC 32 ("Data Management and Interchange") to be "Big Data" related. This includes a Technical Paper published in March of 2017, "ISO/IEC TR 19075-6:2017 Information technology — Database languages — SQL Technical Reports — Part 6: SQL support for JavaScript Object Notation (JSON)," and a 2016 Technical Report on SQL support for streaming data, "ISO/IEC AWI (Approved Work Item) TR 29075-1: Information technology — Data management and interchange — Design notes for new database language technologies — Part 1: SQL support for streaming data."[276] The latter is still under consideration, but Chinese media boast that it was the country's first proposed international standard on Big Data.[277]

UPCOMING WORK ITEMS

According to a May 2022 presentation by Wo Chang, convenor of the "Data" Working Group under SC 42, a Chinese Editor is overseeing the development of "ISO/IEC 5259-4 (IS) Data quality for analytics and machine learning (ML): Part 4: Data quality process framework," which is currently in the drafting process.[278]

ARTIFICIAL INTELLIGENCE

AI IN ITU

China is guiding some of the most seminal AI standards in ITU, but does not dominate participation in Focus Groups on this issue.

FOCUS GROUPS

ITU-T classifies Artificial Intelligence (AI) as an "area of action," indicating that it is a broad focus addressed across ITU's Study Groups. There are eight specified focuses within AI: the AI for Good Global Summit, Machine Learning for 5G networks, AI for Health, AI and emerging radio technologies, Environmental Efficiency for AI, AI for autonomous and assisted driving, AI for Natural Disaster Management, and an AI Repository.[279]

There are several notable Focus Groups working on AI-related issues, but only a few of them have significant Chinese involvement – a departure from China's typically high engagement levels at ITU.

There are two Focus Groups China engages in frequently. One is the Focus Group on Artificial Intelligence (AI) and Internet of Things (IoT) for Digital Agriculture (FG-AI4A). While the highest-level leadership for the FG-AI4A is not Chinese, there are three Vice-Chairs from Chinese companies (the U.S. has two, while all other countries have one or none). Each of the Working Groups within the Focus Group have a Chinese Chair or Vice-Chair, two of the three Topic Groups with specified leaders have Chinese leaders.[280] The other main Focus Group related to AI that China works on is the Focus Group on Environmental Efficiency for Artificial Intelligence and other Emerging Technologies (FG-AI4EE). This group has a Huawei employee as a Chair (Paolo Gemma), another Chinese Vice-Chair, and Chinese Chairs for two of the three Working Groups.[281]

RECOMMENDATIONS AND WORK ITEMS

ITU-T began its first Work Items related to AI in the 2017-2020 Work Period. There were 28 different Work Items related to AI introduced during this period, addressing 18 different Questions. 19 of the Work Items had Chinese Editors or Supporting Members.[282] China engaged on topics ranging from AI-enabled networking, to AI cloud platforms, to IoT and AI.

The Question with the most AI-related Work Items during this period (five) was Question 5 in Study Group 16. This Question is on "Artificial intelligence-enabled multimedia applications." Each of the Work Items related to AI during the 2017-2020 period and the current Work Period were proposed by China.[283] The rapporteurs for this Question are also both Chinese.[284]

China is currently Editing two of the most seminal Work Items related to AI in the current Work Period. One is the "Artificial Intelligence Standardization Roadmap," which has one, Chinese Editor. This "high priority" Supplement will lay out the current state of AI standards and establish the gaps for future AI standardization.[285] The second is the "Challenges of and Guidelines to Standardization on Artificial Intelligence of Things [AIoT]," which will define a "clear direction for AIoT standardization." This Recommendation is being co-drafted by Chinese Editors from China Unicom and ZTE, and Korean Editors from ETRI and the Korea Advanced Institute of Science and Technology (KAIST).[286]

UPCOMING WORK ITEMS

In the 2022-2024 Work Period, 11 of the 19 Work Items related to AI have Chinese Editors. Most of the Work Items that have at least one Chinese Editor have *only* Chinese Editors and Supporting Members. Some of these are IoT-related, focusing on specific IoT applications. Three of the Work Items focus on the cloud computing aspects of Artificial Intelligence.[287]

AI IN ISO

China has low levels of leadership and editorship on AI in ISO, indicating that this is not an area where China is particularly influential.

SUBCOMMITTEES

In October of 2017, ISO/IEC JTC 1 voted to establish Subcommittee 42 (SC 42, "Artificial Intelligence"). The group is intended to look at all AI-related standards across ISO and IEC, with focuses ranging including "foundational AI standards, Data standards related to AI, Big Data and Analytics, AI trustworthiness, use cases and applications, governance implications of AI, computational approaches of AI, ethical and societal concerns." SC 42 is led by a U.S. Chair and Committee Manager, with a Canadian convenor.[288]

There are two Chinese officers in SC 42/WG 5, which examines "Computational Approaches and Computational Characteristics of AI Systems (Current)." This project was previously SG 1, which was completed in 2019 and then reopened as a Working Group.[289]

UPCOMING WORK ITEMS

According to Chinese media reporting, "ISO/IEC TR 24372: Information technology — Artificial Intelligence (AI) — Overview of computational approaches for AI systems," was the first ISO/IEC AI-related Technical Report written by China.[290] This proposal was led by representatives from iFlyTek.[291]

Under SC 42, there are only five out of 32 work items in process with a Chinese Editor (one of the five has Chinese and U.S. co-Editors). One of these work items is related to Big Data (falling under WG 2). One, "ISO/IEC TS (Technical Specification) 8200 Information technology — Artificial intelligence — Controllability of automated artificial intelligence systems," falls under WG 3 ("Trustworthiness"). The remaining three fall under the one Working Group that China oversees, WG 5. These projects are "ISO/IEC TR 24372: Information technology — Artificial Intelligence (AI) — Overview of computational approaches for AI systems," "ISO/IEC TS 4213 Artificial intelligence – Assessment of machine learning classification performance," and "ISO/IEC 5392 Information technology — Artificial intelligence — Reference architecture of knowledge engineering."[292] All of the Chinese-only standards are being developed by iFlyTek.[293]

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