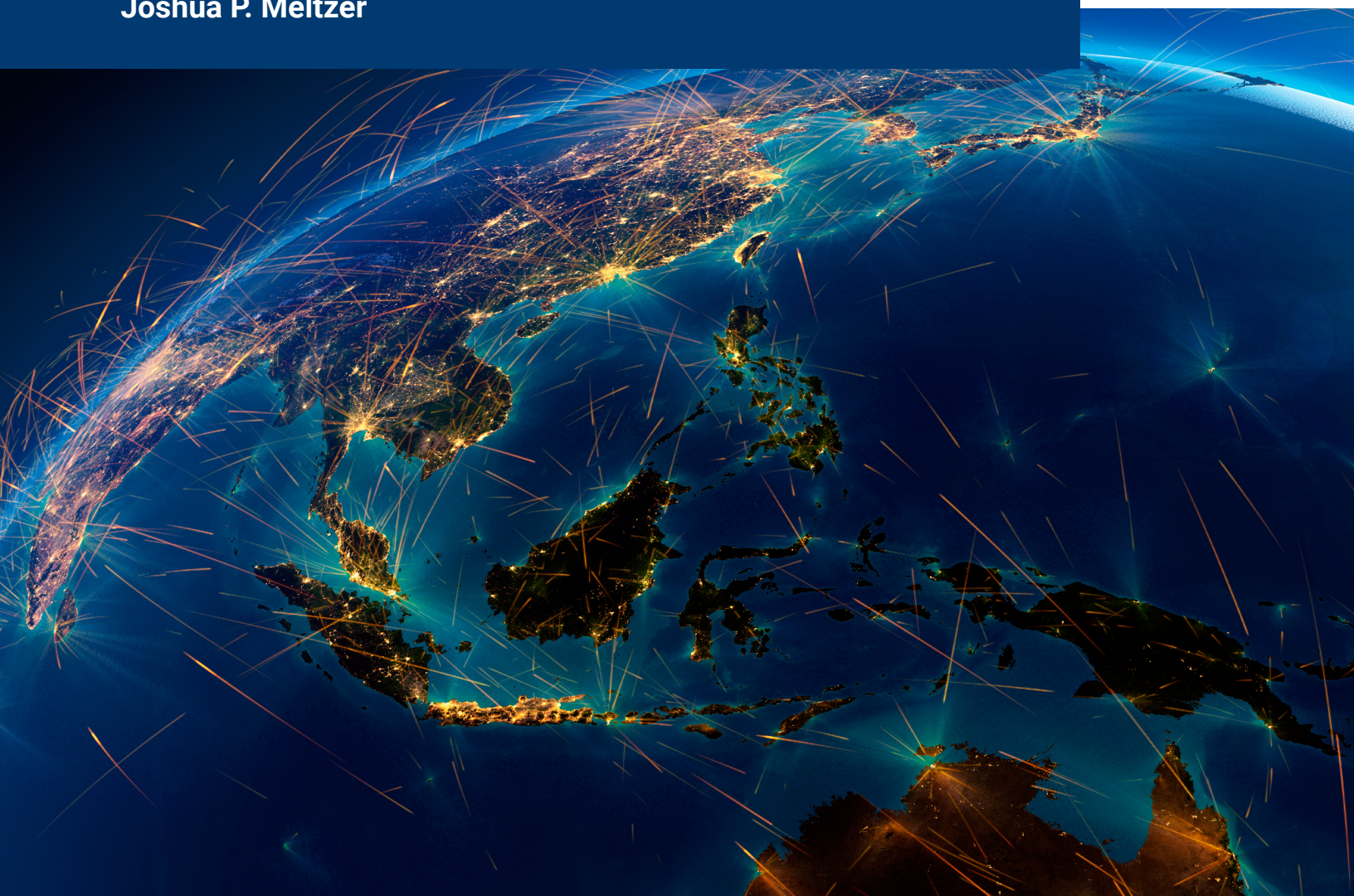
Global Economy and Development at BROOKINGS

REPORT
SEPTEMBER 2022

A CRITICAL TECHNOLOGY STANDARDS METRIC

ASSESSING THE DEVELOPMENT OF CRITICAL TECHNOLOGY STANDARDS IN THE ASIA-PACIFIC

Joshua P. Meltzer



Global Economy and Development at BROOKINGS

JOSHUA P. MELTZER is a senior fellow in the Global Economy and Development Program at Brookings.

ABOUT GLOBAL CONOMY AND DEVELOPMENT:
Founded in 2006, the Global Economy and Development program at Brookings aims to shape the policy debate on how to improve global economic cooperation and fight global poverty and sources of social stress.

ACKNOWLEDGEMENT:
This project was made possible with support from the Australian Government through the Cyber and Critical Tech Cooperation Program, Department of Foreign Affairs and Trade. The views expressed in this publication are the author's alone and are not necessarily the views of the Australian Government. The Brookings Institution is committed to developing independent, non-partisan analysis and recommendations that reflect objective and rigorous scholarship.

The author expresses gratitude to all the questionnaire respondents and interviewees from government, industry and civil society in all of the countries in the CTSM. The author is also thankful for the excellent research support from Nusrat Chowdhury. The author is grateful to our reviewers and extends thanks to Junjie Ren and Jeannine Ajello for their communications support in this publication.

PHOTO CREDIT: Shutterstock. Country profile maps are artistic illustrations and should not be considered true-to-scale and representative of a country's territory.

CONTENT

Introduction

The development and use of critical technologies such as artificial intelligence (AI), quantum computing, and cloud computing are increasingly a focus of government policy, R&D budgets, and investment. This trend reflects the critical role of technology in relation to economic growth, jobs, and national security. Critical technologies are also central to the intensifying strategic competition between the West and China, given the importance of technology for developing and sustaining leading-edge economies and the dual-use potential of many critical technologies with implications for national security.

The significance of critical technologies has led to governments, industries, and civil society organizations to pay growing attention to the development and use of critical technology standards (CTS). Standards shape global markets and effect which technologies become market leaders. Standards also shape the values that technologies embody. For instance, standards as to what is trustworthy and reliable AI will guide AI development globally.

This project developed a Critical Technology Standards Metric (CTSM) that assesses the capacity of countries in the Asia-Pacific region to engage in the development and use of CTS and allows for cross-country comparison of CTS capacity. The CTSM is based on data collected from a questionnaire sent to government officials, industry, and civil society in a selection of countries, as well as our own research and analysis.

The countries in the CTSM are Australia, Cambodia, Indonesia, Malaysia, Philippines, Singapore, and Vietnam. These countries represent different levels of development and have varying uses of critical technologies in their economies. Indeed, countries such as Vietnam, Indonesia, and Singapore are already established or are becoming established technology hubs. Australia has a strong R&D base and expertise in areas such as quantum computing and AI, whereas a country such as Cambodia is still early in terms of its capacity to use digital technologies. How these countries' government, industry and civil society engage with the standards bodies that are producing CTS as well as use CTS, will have implications for the uptake of critical technologies with important effects on economic growth, engagement in international trade, and national security.

What is critical technology

The CTSM is focused on critical technologies, however, there is no globally agreed-upon definition of critical technology. For many countries, what makes technologies “critical” is the implications of that technology for the countries’ national security and economic prosperity. For example, Australia defines critical technologies as “emerging technologies with the capacity to significantly enhance or pose risk to our national interests, understood broadly as comprising economic prosperity, social cohesion and/or national security.”[1] Japan defines critical technology as “important technologies in which Japan should maintain superiority and remove vulnerabilities in order to ensure Japan’s security and realize the sound development of the Japanese economy.”[2] The U.S. defines critical and emerging technologies as “advanced technologies that are potentially significant to US national security.”[3] This broadly common ap-

proach and definition has also led to some convergence as to which technologies are critical.

As part of the CTSM, we asked respondents from government, industry, and civil society to list the technologies that they consider critical. The following table captures these results. As can be seen, all countries in the CTSM see AI, IoT, quantum computing, blockchain, and cybersecurity as critical technologies. There are also significant overlaps in interest when it comes to cloud computing, 5G, and big data, after which consensus among the countries declines. Smart cities and encryption were identified as critical technologies by stakeholders in only three countries. The remaining technologies—autonomous vehicles, space, and biotechnology—had only two countries identify them as critical.

For the purposes of the CTSM, we define critical technology broadly to include the key elements common to how the countries in the CTSM define critical technology, including an open-ended list of what could count as a critical technology.

CTSM definition of critical technology

Critical technologies are technologies that are important for a country's economic growth and national security. Examples of critical technologies include artificial intelligence, quantum computing, Internet of Things, and blockchain.

TABLE 1

Countries views on what are critical technologies

Technologies	Australia	Cambodia	Indonesia	Malaysia	Philippines	Singapore	Vietnam
Artificial Intelligence/ Machine Learning	x	x	x	x	x	x	x
Internet of Things (IoT)/Smart Grid	x	x	x	x	x	x	x
Quantum Computing	x	x	x	x	x	x	x
Blockchain	x	x	x	x	x	x	x
Cybersecurity	x	x	x	x	x	x	x
Cloud Computing			x	x	x	x	x
5G/Internet Connectivity	x	x	x	x	x		
Big Data	x	x			x	x	
Smart Cities				x	x	x	
Encryption			x	x		x	
Autonomous Vehicles	x				x		
Space Tech/Rocket Launcher/Smart Spaces	x		x				

The economic and strategic impacts of critical technology

The development and use of critical technologies will affect economies globally, creating new opportunities for growth because of rising productivity and greater innovation. This will include opportunities to improve health care access and delivery, expand access to education, to address climate change, and more. For example, according to PwC's Global Artificial Intelligence Study, with accelerated development and uptake of AI, global GDP could be 14 percent or almost $16 trillion higher by 2030.

Critical technologies will also affect job growth and opportunity. The World Economic Forum's 2020 Future of Jobs Report estimates that by 2025, 97 million jobs that are "more adapted to the new division of labor between humans, machines, and algorithms" will be created, and 85 million jobs will be displaced "by a shift in the division of labor between machines and humans" across 26 countries. Boston Consulting Group estimates that by 2030, the United States could face a labor shortfall of over six million jobs in mathematics and computers, while the displacement of workers by technology could lead to a simultaneous labor surplus of three million workers in office and administrative support roles. Even as job creation outpaces job losses, there will be a significant mismatch between the skill sets of those losing jobs and the skills sets required in newer jobs areas of critical technology such as AI/ML, information security, and Internet of Things (IoT).

Critical technologies are also increasingly present across a wide range of sectors. In manufacturing, combining AI and robotics has the potential to eliminate the need for workers to engage in repetitive or dangerous tasks, such as those at stations on an assembly line. AI also has the potential to increasingly replace white-collar jobs and is already automating back-end legal work and high frequency share trading. Efforts in the health care sector to develop of COVID-19 vaccines made headlines for their use of AI systems in mRNA sequencing and clean ing clinical trial data. Quantum technologies offer new opportunities to address cell processes at the nanoscale, allowing scientists to develop "medical tools, diagnostics, and treatments that are both ultra-precise and ultra-personalized."

Critical technologies are also crucial to national security on a variety of fronts. With regard to securing a state's critical infrastructure, AI and other critical technologies can be used to offer "safe, cost-effective, and reliable" service to customers, as well as function as a "predictive tool" for forecasting potential failures. In instances where there is a problem or a failure, AI can supplement human judgement and actions, such as diagnosing problems and deciding on a course of action.

Many of the critical technologies have both civilian and military applications. Military applications for AI include analyzing of intelligence information, such as using facial recognition, enhancing weapons systems with digital infrastructure, and providing strategic recommendations for battlefield scenarios. Quantum technology's applications are currently more nascent, but present major implications for the future. Foremost among these will be quantum computing's ability to trounce encryption technologies of the highest-caliber—an

encryption that would take a conventional supercomputer a billion years to decode could, in theory, be broken by a quantum computer in seconds. Further-off applications include "quantum sensing," which could enhance navigation capabilities and the detection of stealth aircraft or the use of chemical weapons.

Critical technologies can also have system-wide impacts that effect how countries are governed. Already, AI applications have demonstrated how they can—intentionally or otherwise—impact democracies through the abuse of sentiment analysis, the creation of deep fakes, and the amplification of disinformation and misinformation, all of which can facilitate trends of polarization and increase authoritarianism.

Why international critical technology standards matter

CTS will impact the development and use of critical technology, including access to markets, how to manage technology risks and benefits, and what values critical technology embodies, with implications for societies and forms of governance.

When it comes to creating global markets, CTS can underpin interoperability among technologies that allow for scale, efficiency, and increased access to technology. For example, Wi-Fi is a radio technology built on a series of technology standards. USB is a standard that allows for common connections of cables and charging and exchanging data on a wide range of devices, and IPv4 is a standard that defines IP addresses for the internet. Industry often orientates production around international CTS, allowing for scale. For SMEs in particular, CTS can help them engage in international trade as common standards mitigate the costs of retooling technology to access new markets.

For example, CTS standards are already being developed in areas of risk management for AI, data governance, as well as the technical documentation that can establish compliance with regulation of high-risk AI systems.[4] International AI standards will also be needed to develop commonly accepted labelling practices that can facilitate B2B contracting and demonstrate conformity with AI regulations. For instance, under the proposed AI Act, conformity with AI standards will create a presumption of conformity with the act.[5]

What is a standard?

Standards codify technical knowledge in rules, conditions, or guidelines for products, processes, production methods, and related management systems practices. The ISO/IEC defines a standard as "a document, established by consensus and approved by a recognized body, that provides for common and related use, rules, guidelines or characteristics for activities or their results, aimed at the achievement of the optimum degree of order in a given context."

How are critical technology standards developed

The focus of the CTSM is on CTS developed by multi-stakeholder, industry-led, global standards development bodies (SDOs) such as the ISO (International Organization for Standardization), IEC (International Electrotechnical Commission), the IEEE (Institute of Electrical and Electronics Engineers) and ITU-T (International Telecommunication Union-Telecommunication Standardization Sector), where many of the key international technology standards have been developed. For example, the ISO/IEC in 2017 established JTC 1/SC 42, where work is underway on a range of AI standards, including on AI risk assessment, algorithmic bias, and determination of AI trustworthiness, as well as CTS standards relevant for cloud computing and IoT. The IEEE—an international body also working on technology standards—is addressing the intersection of technology and ethics for AI, which includes work on algorithmic bias and a model process for addressing ethical concerns during system design.[66]

The importance of CTS developed in these global SDOs has been affirmed in various leader-level statements. The 2021 G7 leaders communique included commitments of support for "industry-led inclusive multi-stakeholder approaches to standard setting," and endorsed the "Framework for G7 Collaboration on Digital Technical Standards," a set of steps the G7 will take to strengthen international cooperation with respect to digital technical standards.[7] At the 2020 G20 there was a call to action by the heads of the IEC, ISO, and ITU to "recognize, support and adopt international standards to accelerate digital transformation in all sectors of the economy."[8]

A defining feature of these global SDOs is that they are multi-stakeholder and industry-led. Governments and civil society participate alongside the private sector. This set-up reflects the view that standards development is technical and expert-driven and requires industry experience with the development and use of these technologies.

International standards developed by these global SDOs are also based on consensus and are voluntary, in that it remains up to governments and business whether to use them. Despite being voluntary, many CTS can have significant effects within countries and for international trade. For example, previous ISO/IEC standards have a history of being adopted by companies globally, becoming the de facto standards for market access. In addition, governments reference ISO/IEC standards in domestic laws or regulations, making them in effect binding.[9] International standards are also often benchmarks in contracts and a basis for industry self-regulation.

The World Trade Organization (WTO) reinforces the centrality of standards developed by consensus-based voluntary standards bodies. The WTO TBT Agreement provides a commitment to base domestic standards on relevant international standards. The WTO has also developed six principles to guide preparation of international standards, namely: 1). Transparency, 2). Openness, 3). Impartiality and consensus, 4). Effectiveness and relevance, 5). Coherence, and 6). addressing the concerns of developing countries.

TABLE 2

Global SDOs operating procedures and membership

	Operation	Membership
International Electrotechnical Commission (IEC)	Not-for-profit, quasi-governmental international organization.	The IEC is composed of National Committees (one per country) that appoint experts and delegates from industry, government bodies, associations, and academia to participate in the work of the IEC.
Institute of Electrical and Electronics Engineers (IEEE)	Non-profit, technical professional association IEEE Standards Association (IEEE SA) is the standards setting body within the IEEE.	IEEE SA Working Groups are open groups comprised of individuals for individual standards projects, while corporate standards projects are comprised of representatives from corporations, government agencies, and academic institutions.
International Organization for Standardization (ISO)	Quasi-governmental international organization Global network of national standard setting bodies.	Full members (member bodies) participate and vote in ISO technical and policy meetings Correspondent members attend ISO technical and policy meetings as observers and have no voting rights Subscriber members take notice of the ISO's work but do not participate in it
International Telecommunication Union Telecommunication Standardization Sector (ITU-T)	The ITU is the United Nations specialized agency for information and communication technologies (ICTs). ITU-T develops standards through multistakeholder study groups.[10]	Sector member can access all ITU-T Study Groups and the full range of ITU-T activities. Associate can participate in one chosen Study Group. Academia can access all ITU-T study groups.[11]

Main findings

This section provides an overview of the CTSM outcomes with cross-country comparisons, and the following part has country profiles that summarize the key findings for each country. Table 1 in Annex 4 shows the scores for each category and for each country. In the CTSM, each category—governance, participation, and capacity—comprises three to four subcategories, and each subcategory itself is based on data derived from the questionnaire and our own research and analysis. The CTSM methodology and questionnaire are available in Annexes 1-3. The full range of data points underlying each sub-category is available in the interactive table at this link.

As the CTSM shows, the level of CTS capacity in the region is largely developing, with some areas of maturity across many of the countries, but advanced capacity around CTS is scarce and confined to Australia and Singapore. At the other end, there was little evidence of underdeveloped CTS capacity overall. Where it esists, it is mainly confined to specific areas almost exclusively in Cambodia. This outcome is consistent with the overall view of a region that is aware of the importance of CTS for their economies and societies.

With respect to specific countries, the aggregate scores show Australia (78) with the most mature level of CTS capacity, followed by Singapore (75), after which there is a larger gap to Malaysia and the Philippines which are tied (69), then Indonesia (68), Vietnam (64), and finally Cambodia (62), all of which have developing levels of CTS capacity. While no country registered as having an overall advanced level of CTS capacity, beneath these aggregate scores are significant variations of their governance, participation, and capacity, with some areas of advanced capacity, as occurs in Australia and Singapore, particularly when it comes to industry participation in CTS development.

GOVERNANCE

The governance category in the CTSM comprises three subcategories measuring: 1). Legislation and policy as they relate to CTS, 2). Levels of coordination among government, industry and civil society, and 3). Government engagement with industry and with civil society. When it comes to having legislation/policy on CTS, many countries have something on the books or are developing CTS strategies. For instance, Singapore (81), Australia (78), the Philippines (74), and Malaysia (74) already have relatively mature laws, regulations, and institution governing CTS (See Box 1). Singapore for example has CTS relevant laws and a very capable national standards body, Enterprise Singapore, that coordinates effectively with industry and civil society, as well as a single government agency that is responsible for governments' standards work and coordination with other government agencies. In contrast, Vietnam (66) does not have laws specific to CTS, and while it has a peak standards body—STAMEQ—responsibility for CTS is spread among government agencies, with less effective coordination among the government on CTS and low levels of government engagement with industry and civil society on CTS.

Coordination among stakeholders is another key area of focus in determining levels of CTS governance. This reflects the importance of engagement and coordination among stakeholders when developing CTS. The CTSM assesses coordination among government,

industry, and civil society—the capacity for intra-stakeholder coordination—as well as the level of government engagement with industry and civil society on CTS. As the CTSM shows, intra-stakeholder coordination is generally a weak point.

There is a cohort of governments, namely the Philippines (68), Singapore (67), Malaysia (65), and Indonesia (65), that have developing levels of intra-stakeholder coordination, while Vietnam (60) and Cambodia's (53) levels of intra-stakeholder coordination are underdeveloped. In contrast to intra-stakeholder coordination, government engagement with industry and civil society on CTS performs better. On this metric, Indonesia (70), the Philippines (70), and Singapore (70) have very similar capacity and levels of effectiveness, while Vietnam (66), Malaysia (66), and Cambodia (66) were on the lower end, due to little to no engagement by the government with civil society, particularly on CTS. In Australia (80), government engagement with civil society is mature, with Standards Australia playing a key coordinating role.

BOX 1

Governance

Measured in legislation and policy, government/ industry/ civil society coordination, and government engagement with industry/ civil society.

Note: 50-60: Underdeveloped; 61-70: Developing; 71-80: Mature; 81-100: Advanced.

SOURCE: Meltzer, Joshua P. Critical Technology Standards Metric. The Brookings Institution 2022.

PARTICIPATION

What counts as participation in the CTSM comprises four categories, three of which capture the extent of government, industry, and civil society participation in the development of CTS and the fourth being financing for participation in SDOs and for CTS research.

Levels of participation in standards bodies vary among the CTSM countries (see Box 2). Generally, industry participation and contribution to CTS in SDOs is more regular and effective than that of government or civil society. This likely reflects the importance of CTS for industry and the role of industry in bringing expertise and experience in critical technologies to the SDO process. For instance, in Australia (90) and Singapore (90), industry participation is advanced, whereas participation by these countries' governments in CTS development was a notch lower for Australia (76) and Singapore (83). Vietnam bucked this trend with government participating in CTS development more than industry and civil society (70 versus 66). The Philippines (71)

BOX 2

Participation

Measured in government/ industry/ civil society participation in CTS development and financial support.

Note: 50-60: Underdeveloped; 61-70: Developing; 71-80: Mature; 81-100: Advanced.

SOURCE: Meltzer, Joshua P. Critical Technology Standards Metric. The Brookings Institution 2022.

has very similar participation by government and industry in SDOs. These outcomes likely reflect a greater role for government in Vietnam and the Philippines when it comes to CTS development. In terms of how often industry participate in global SDOs, there is also a range, with industry representatives from Australia and Singapore reporting significantly higher levels of participation—up to monthly—compared to industry participation from other countries in the CTSM of one to four times annually.

When it comes to participation in global SDOs by government, Singapore (83) scored highest, followed by Australia (76), with the rest of the governments in the CTSM showing developing levels of government participation. Lower levels of participation in global SDOs was often due to a combination of financial constraints, a focus on domestic standards development, and limited knowledge of the CTS being developed in global SDOs.

There was also a range of levels of participation by civil society in CTS. Australia (78), Singapore (71) and the Philippines (71) have mature levels of civil society participation, whereas in Indonesia (69), Malaysia (67) and Vietnam (62), civil society participation was developing, while civil society participation in Cambodia (58) scored the lowest. In most countries in the CTSM, participation by civil society in CTS development was also lower than that of government and industry. In fact, civil society participation is relatively weak across the countries in the CTSM. This seems to be due to the limited capacity to engage in CTS being developed in domestic and especially in global SDOs, and a lack of resources which all stakeholders reported as barriers to participating in global SDOs. In this regard, all countries in the CTSM scored relatively low when it comes to providing financial support for participation in global SDOs.

Government, industry, and civil society in a number of countries in the CTSM reported financing as a barrier to participation in global SDOs. While many governments provide some financial support for participating in SDOs, this was seen as insufficient, particularly in light of the growing complexity and importance of CTS development in global SDOs. In a number of countries in the CTMS such as Cambodia, Malaysia and Vietnam, government support for participation is often tied to leadership roles in a standards-setting process, whereas this was not necessarily the case when it comes to government support provided by Australia, Indonesia and the Philippines. In terms of the adequacy of financial support for research that can contribute to the development of CTS, most countries reported some funding by government, more funding by industry in most cases, and less funding by civil society.

CAPACITY

In terms of capacity, the CTSM measures awareness of CTS, expertise, and workforce skills for implementing and enforcing CTS. There was awareness of the CTS being developed in SDOs across all participating countries, with room to improve. In Australia (73), the level of CTS awareness is highest and mature, followed by Singapore and Malaysia (70), whereas Cambodia (62) has the lowest levels of awareness. While a number of governments do provide some information to industry and civil society as to the CTS being developed in global SDOs, this was consistently reported as being too little and often too late to be helpful.

There is also a range of CTS expertise across the CTSM. Overall, Australia (75) and Singapore (75) have mature levels of expertise, while the rest of the countries' expertise is developing. In

terms of the expertise of specific stakeholders, industry has more of the expertise needed to effectively engage in CTS development in SDOs, whereas CTS expertise in government and civil society was relatively lower.

When it comes to having a workforce that can assess compliance with CTS and have access to CTS training, Australia (77) is mature, with Singapore (70) also has a capable workforce and access to training. At the other end, Vietnam's (53) and Cambodia's (57) workforce capacity and training is underdeveloped. The rest of the countries workforce capacity and training is developing. These results highlight a general lack of capacity to enforce compliance with CTS, as well as the need for training.

BOX 3

Capacity

Measured in awareness, expertise, and workforce.

Note: 50-60: Underdeveloped; 61-70: Developing; 71-80: Mature; 81-100: Advanced.

SOURCE: Meltzer, Joshua P. Critical Technology Standards Metric. The Brookings Institution 2022.

AUSTRALIA
COUNTRY PROFILE

Overall score: 78

Australia's approach to CTS is industry-led with active participation and support from the government and civil society. Australia has a well-developed approach to engaging with key global standards bodies such as the ISO, the IEC, and the ITU-T. Current critical technology standards that Australia is focused on are AI, smart cities, cyber security, IoT, blockchain, and data governance.

GOVERNANCE

Legislation and Policy: 78

Australia has a mature legislative and policy framework when it comes to CTS. Australia's standardization process is open and inclusive and involves government, industry, and civil society.

Australia also has a well-developed program for supporting CTS development globally. The International Cyber and Critical Technology Engagement Strategy (CCTS) 2021 aims to shape CTS that will foster interoperability, diverse markets, and security by design in the Asia-Pacific. The strategy also supports engagement with key multi-stakeholder SDOs such as the ISO, the IEC, and regional SDOs in the Asia-Pacific region. The Digital Trade Strategy compliments the CCTS and focuses on adopting and implementing international standards into domestic frameworks.[12]

Australia's approach to standardization generally, as well as CTS specifically, is industry-led and consensus driven with participation of experts from industry, academia, and government. Standards Australia is the peak non-government standards body that facilitates the development of Australian standards and participates in global SDOs. Australia also has a range of industry bodies such as the Australian Information Industry Association (AIIA), the Australian Computer Society (ACS), and the Information Technology Professionals that are engaged in developing standards, and coordinate work on CTS with Standards Australia.[13]

The Australian government is generally also an active participant in standards development and funds participation in global SDOs. Complying with international CTS developed by SDOs is voluntary. However, domestic CTS are often based on international CTS developed in global SDOs such as ISO, IEC, and others. In Australia, these voluntary CTS often become mandatory for business and government when referenced in government regulation and in business-to-business contracting.

Government/Industry/Civil Society Coordination: 77

Overall, there is good coordination within government, industry, and civil society on CTS. When it comes to the government, federal level responsibility for CTS is split among the Department of Communications, the Department of Foreign Affairs and Trade, and the Department of Industry. Standards Australia plays a central role in facilitating discussion on CTS among industry, as well as with local, state, and federal governments.

However, coordination among government agencies appears less robust compared to industry coordination around CTS, pointing to room for improvement.

Government Engagement with Industry/Civil Society: 80

Overall, there is a well-developed process for government to engage with industry and civil society when it comes to developing CTS.

Again, Standards Australia plays an important role connecting government officials and civil society with the industry-led standards making processes. Specifically, when developing standards, Standards Australia convenes technical committees that mirror the work done in the global SDOs and includes representatives from government, industry, and civil society. In addition, Standards Australia opens standards for public comment, providing another avenue for input from a broad range of stakeholders.

PARTICIPATION

Government Participation in CTS Development: 76

There is regular (often monthly) participation of government officials in global standard setting bodies such as ISO/IEC/JTC1, ITU-T, and IEEE.

However, the actual contribution of government officials to CTS development scored lower, compared to industry and civil society. Some of this might reflect

the industry-led nature of the standards process and the focus of technical expertise in industry. However, it also points to areas where the government could strengthen its own technical expertise to better support the CTS process.

Industry Participation in CTS Development: 90

Industry consistently participates and contributes to both domestic and international standard setting, reflecting an advanced level of contribution to CTS development. Representatives from industry participate in global SDOs such as ISO/IEC/JTC1, ITU-T, and the IEEE, often at a rate of over 20 times per year. Industry focus on CTS includes AI, IoT, smart cities, quantum computing, data sharing, cyber security, smart manufacturing, and transport.

Civil Society Participation in CTS Development: 78

The participation and contribution by civil society in Australia to CTS development is mature and scored the highest compared to other countries in the CTSM. Civil society is a regular participant in CTS development in both domestic and global SDOs such as ISO/IEC/JTC1, IEEE, and ITU-T. The CTS that civil society are focused on are nanotechnology, biometrics, cyber security, health informatics, cloud computing, IoT, and AI.

Financial Support: 74

Financial support in Australia for participating in developing CTS in SDOs is mature, but with room to strengthen. When it comes to financial support to participate in global SDOs, industry is not lacking, but more could be done to support participation by government officials and civil society. Although there is no fee for participation in ISO and IEC activities, the resources required to participate in global SDOs can be restrictive. Other global SDOs charge fees for participation which can be onerous for civil society.

When it comes to funding research that can support CTS development, industry is the main player, and while government and civil society are also funding research, there is also room here for additional resources.

CAPACITY

Awareness: 73

The level of awareness and timeliness of information on CTS development in Australia is mature with room for improvement, although it scored the highest among countries in the CTSM. Government, industry, and civil society are broadly aware of which CTS are being developed in global SDOs. The government plays a limited role in informing industry and civil society of CTS development. When information is provided it is often not considered timely. This partly reflects the role that Standards Australia plays in providing information to stakeholders. When it comes to awareness of gender implications in setting CTS, there was a range of levels of awareness across government, industry, and civil society, also pointing to where more could be done.

Expertise: 75

Australia has a range of expertise when it comes to developing and implementing CTS, with industry expertise being mature and expertise among government and civil society scored as developing. That said, Australia's overall levels of expertise is the same as Singapore and significantly better than the other countries in the region that participated in the CTSM.

Workforce: 77

Australia has a mature workforce capable of assessing compliance with CTS. However, more could be done in terms of training and education on CTS development and compliance, particularly as CTS grows in complexity and importance. This may involve innovative training programs such as the government's collaboration with Standards Australia to provide training programs to increase skills in critical and emerging technology standards.

CAMBODIA COUNTRY PROFILE

Overall score: 62

Cambodia's overall score in the CTSM is the lowest compared to other countries in the region, with significant room for improvement when it comes to CTS governance, participation, and capacity. Cambodia lacks a standardization infrastructure which engages industry and civil society in the standard development process. Where government, industry, and civil society participate in CTS development they are domestically focused, with little to no participation in global SDOs. Additionally, the country falls short in having the skilled workforce to develop, implement, and assess compliance with CTS. The critical technologies that Cambodia is focusing on are AI, IoT, cybersecurity, big data, 5G, cloud computing, and quantum computing.

GOVERNANCE

Legislation and Policy: 64

Cambodia's legislation and policy for CTS is developing, with substantial room for improvement. It scored the lowest in the CTSM on this metric, slightly lower than Indonesia (65) and Vietnam (66), and well below regional leaders Singapore (81) and Australia (78).

The Institute of Standards of Cambodia (ISC) under the Ministry of Industry, Science, Technology & Innovation (MISTI) is the main national standard body responsible for the development and implementation of CTS. Within ISC, the National Standard Council is responsible for approving and reviewing standards. ISC is a member of global SDOs such as the International Organization for Standardization (ISO), the International Electrotechnical Commission (IEC), and regional SDOs such as ASEAN Consultative Committee on Standards and Quality (ACCSQ).

Cambodia does have regulations for general standards development, but the regulations do not address the adoption of international standards into Cambodian standards, i.e., there is no requirement to base domestic standards on international standards. Cambodia's standards are voluntary but can be designated as mandatory where it is in the interest of public safety, and industry.

Cambodia does not have a national strategy that addresses CTS development and adoption. The 2021 Cambodia Digital Economy and Society Policy Framework aims to integrate digital technology into the public sector by establishing ICT infrastructure and cybersecurity standards as well as encouraging the use of technologies such as AI, big data, and IoT.

Government/Industry/Civil Society Coordination: 53

Coordination among stakeholders on CTS is underdeveloped and is the lowest in the CTSM. Coordination among government agencies on CTS is lacking. There is very limited coordination among industry or among civil society—a key gap in Cambodia's capacity for CTS development.

Government Engagement with Industry/Civil Society: 66

Cambodia scored in the lower end of the group for government engagement with industry and civil society on CTS, tying with Malaysia and Vietnam. The National Standards Council does have some representation from national universities, producer and consumer associations, as well as the Cambodia Chamber of Commerce. However, industry and civil society do not seem able to propose CTS for development, nor do they participate in CTS development.

PARTICIPATION

Government Participation in CTS Development: 67

Government participation in CTS is developing, scoring the lowest in this metric along with Indonesia.

Government officials are focused on domestic CTS development, rather than CTS in global SDOs. Cambodian government officials participate in global SDOs such as ISO/IEC, and ITU-T one to four times annually, consistent with engagement by many of the other governments in the region, and in contrast to Singapore and Australia where participation is approximately monthly.

The critical technologies the Cambodian government is focusing on are IoT, blockchain, AI, cybersecurity, e-commerce, and smart manufacturing.

Industry Participation in CTS Development: 67

Cambodia scored in the lower end of the range in terms of industry participation in CTS development. Industry participates in domestic CTS development sometimes, however, the frequency of participation and quality of contribution could be improved. When it comes to global SDOs, Cambodian industry representatives do not attend these meetings at all.

The critical technologies Cambodian industry is focusing on are AI, IoT, and blockchain.

Civil Society Participation in CTS Development: 58

Civil society participation in CTS development is underdeveloped and scored the lowest compared to other countries in the CTSM. There is very limited civil society participation in both domestic and global SDOs.

The critical technologies civil society is focusing on are blockchain and AI.

Financial Support: 56

Financial support for CTS development in Cambodia is underdeveloped and scored the lowest in the CTSM. Having said this, all countries in the CTSM scored relatively low when it comes to financial support. The highest score of 74 was awarded to Australia.

The Cambodian government reported having no financial resources to participate in global SDOs, while civil society and industry representatives reported insufficient funds to participate in global SDOs. The government also do not provide financial assistance to industry or civil society to participate in global SDOs.

In terms of funding research that supports CTS development, industry does not fund any research. The government and civil society do fund limited research into CTS, though this funding is inadequate.

CAPACITY

Awareness: 62

Levels of awareness of CTS in Cambodia is the lowest in the CTSM. Industry and civil society do not receive information from the government on the CTS being developed in the global SDOs. There is some awareness of gender implications in developing CTS.

Expertise: 68

When it comes to expertise on CTS, all stakeholders (government, industry, and civil society) reported having some knowledge of the technologies and CTS being developed. Industry and civil society have some experience implementing CTS, while the government reported little to no such experience.

Workforce: 57

Cambodia's workforce capacity when it comes to CTS is underdeveloped and scored lower than all countries in the CTSM, except for Vietnam. Cambodia does not have the skilled workforce to access compliance of CTS in the country. Government provides very limited training for CTS development and compliance.

INDONESIA COUNTRY PROFILE

Overall score: 68

Indonesia's legislation and policy for CTS is relatively underdeveloped compared to the other countries in this CTSM, scoring only slightly better than Cambodia (64)—a significantly smaller and less developed economy—and just better than Vietnam (66).

Indonesia's standardization of critical technology is government-led. In addition to the process of adopting CTS, Indonesia's coordination of CTS development within government could be improved. Indonesia's industry participation in CTS is particularly strong, but Indonesia lacks the workforce required to strengthen CTS development and to assess compliance. The critical technologies Indonesia is focusing on are AI, IoT, big data, cloud, 5G, blockchain, and cybersecurity.

GOVERNANCE

Legislation and Policy: 65

There is no singular strategy that Indonesia has adopted regarding critical technology, similar to most other countries in the CTSM. It has, instead, several technology strategies, such as the National Research and Innovation Agency (BRIN)'s National Strategy for Artificial Intelligence as well as other critical technologies such as IoT, advanced robotics, augmented reality (AR), and 3D printing. The strategy also emphasizes the need to set national standards for adopting AI innovations.[14]

Indonesia's standardization process is government led, and Badan Standardisasi Nasional (BSN) is the country's national standardization agency which is responsible for formation, adaptation, and implementation of CTS. BSN is the point of contact for WTO/TBT enquiries and represents Indonesia in international standard setting bodies such as ISO/IEC and regional SDOs such as ACCSQ (ASEAN Consultative Committee for Standards and Quality) and PASC (Pacific Area Standards Congress).

Indonesian National Standards (SNI) are adopted or formulated by the technical committees within BSN, they are voluntary but can be enforced by the government for reasons including national security and safety, environmental protection, and public health. BSN is required to adopt international standards from ISO/IEC but provides scope for domestic standards to diverge from international standards when required by local conditions.

Responsibility for CTS is split among the Directorate of Development of Mechanics, Energy, Electrotechnics, Transportation, and Information Technology, which has responsibility for policies relating to CTS development, and the National Cyber and Encryption Agency (BSSN), which is responsible for CTS related to cyber security and encryption.[15]

Government/Industry/Civil Society Coordination: 65

Coordination among Indonesia's government agencies on CTS is limited. Coordination among industry and among civil society on CTS appears somewhat better but also with scope for improvement.

Government Engagement with Industry/Civil Society: 70

Indonesia scored in the upper middle end of the group when it comes to government engagement with industry and civil society on CTS, scoring the same as Singapore and the Philippines but less than Australia, which has a mature level of government engagement (80).

PARTICIPATION

Government Participation in CTS Development: 67

Indonesian government officials participate in and contribute to the development of domestic CTS as well as CTS developed in global SDOs. However, the government's level of participation in CTS development in both global and domestic SDOs is developing and at the lower end compared with other countries in the region, tying with Cambodia (67) and well below regional leaders Australia (76) and Singapore (83).

Government officials participate in global SDOs such as ISO/IEC, ITU-T and IEEE, one to four times annually, consistent with engagement of many of the other governments in the region, and in contrast to Singapore and Australia where participation is often monthly.

The CTS the Indonesian government is currently focusing on are AI, IoT, big data, cloud, 5G, blockchain and cybersecurity.

Industry Participation in CTS Development: 77

Industry participation and contribution to CTS development domestically and in global SDOs is mature in Indonesia and is relatively strong compared to its regional counterparts Malaysia (74) and the Philippines (71). However, more can be done to improve industry's frequency of participation in global SDOs.

Industry representatives attend meetings in international SDOs such as ISO/IEC, ITU-T and IEEE one to four times a year, which is lower than the regional leaders Australia and Singapore where industry representatives attend global SDOs monthly.

Civil Society Participation in CTS Development: 69

In contrast, the participation and contribution of Malaysia's civil society to CTS is developing, scoring less than the Philippines (71), Singapore (71) and Australia (78), pointing to room to increase and strengthened participation. Civil society participates in both domestic and global SDOs such as ISO/IEC, IEEE and ITU-T, one to four times annually.

Financial Support: 72

Financial support for CTS development in Indonesia is mature and relatively robust when compared with other countries in the CTSM, second only to the level of financial support offered in Australia (74).

Government partially funds participation in global SDOs but additional funding would support greater attendance at global SDOs, particularly by civil society. Civil society reported that the expense to participate in the critical technology meetings in global SDOs is a barrier to their participation.

In terms of funding research that supports CTS development, industry funds more research than government and civil society, consistent with industries relative higher involvement in CTS development overall.

CAPACITY

Awareness: 65

The overall level of awareness of CTS in Indonesia is in the middle of the CTSM, higher than in the Philippines (63) and Cambodia (62), but less than in Singapore (70), Malaysia (70) and Australia (73). In Indonesia, all stakeholders reported some awareness of the CTS being developed domestically and in global SDOs. The government does inform industry and civil society of the CTS being developed in global SDOs. However, this information is only sometimes timely. There was also some awareness of the gender implications of CTS.

Expertise: 70

Indonesia has relatively good domestic expertise in CTS development, second only to Australia (75) and Singapore (75).

However, the level of expertise varies depending on the type of critical technology. Additionally, government, industry and civil society have only limited experience implementing CTS developed in the global SDOs.

Workforce: 60

Indonesia has a relatively low-skilled workforce when it comes to CTS development and implementation, compared to its peers Malaysia (67) and the Philippines (63). This includes gaps in workforce capacity to assess CTS compliance and auditing. There are some initiatives from government aimed at improving knowledge of CTS implementation, for example, BSN have courses and online training on standards, their implementation and compliance with standards produced in global SDOs.[16]

MALAYSIA COUNTRY PROFILE

Overall score: 69

Malaysia's standardization process is government-led, and the country has developed a CTS strategy that is focused on AI, cybersecurity, IoT, cloud computing, big data. However, Malaysia falls short when it comes to implementing its CTS strategies, with particular opportunities to strengthen coordination among government, industry, and civil society on CTS development as well as increased participation by all stakeholders in CTS developed in global SDOs.

GOVERNANCE

Legislation and Policy: 74

Malaysia has a mature legislative and policy framework for CTS, with room for improvement. Under its 2018 National Policy for Industry 4.0, Malaysia established strategies to develop and adopt international standards from recognized SDOs such as ISO/IEC for critical technologies that Malaysia identified as being transformative for industry and its manufacturing sector. The strategy acknowledges a lack of standards for these emerging technologies and aims to increase adoption of international standards to increase industries global interoperability. The National Policy also encourages involving local industry in implementing CTS.

Responsibility for CTS is divided between the Ministry of Science, Technology & Innovation (MOSTI) and the Department of Standards Malaysia under Ministry of International Trade and Industry (MITI).

The standardization process is also supported by SIRIM Berhad, a government organization responsible for research and technology development including CTS in areas such as AI, robotics, quantum computing, IoT, blockchain. SIRIM is also the key standard agency that adopts international standards into local standards and the point of contact for WTO/TBT inquiries.[17] Standards Malaysia is a member of ISO/IEC and regional standards bodies including the Asia-Pacific Economic Cooperation Sub-Committee on Standards and Conformance (APEC-SCSC)[18] and ASEAN Consultative Committee for Standard & Quality (ACCSQ).

Malaysia's standardization process is government-led, with some involvement from industry and civil society. Standards developed by Standards Malaysia/SIRIM Bhd are subject to ministry approval, which also encourages international CTS to be adopted into domestic standards. However, international standards can also be used directly without converting them to Malaysian Standards (MS).[19]

Standards are drafted by Standard Malaysia's National Standards Committees (NSC), and CTS fall under a particular NSC called the industry standard committee (ISC) for Information Technology, Communications and Multimedia which also includes experts from industry. When a standard is produced or adopted by Standards Malaysia they are published online and are publicly available.

Government/Industry/Civil Society Coordination: 65

Coordination among stakeholders is developing with opportunities to strengthen. Coordination among government agencies on CTS is lacking. There is some coordination among Industry and among civil society, but this is also limited and could be improved.

Government Engagement with Industry/Civil Society: 66

Government engagement with industry and civil society is developing and where there is engagement, more could be done to strengthen outcomes that contribute to CTS development and implementation.

PARTICIPATION

Government Participation in CTS Development: 72

There is relatively robust participation by Malaysian government officials in the development of domestic CTS and while Malaysian government officials are also engaged in international CTS, more could be done here to increase participation rates and strengthen capacity to contribute to CTS development.

Government officials participate in global SDOs such as ISO, IEC, ITU-T, and IEEE at times, averaging to one to four times annually. However, participation in global SDOs is relatively low compared to regional leaders Australia and Singapore where officials attend global SDOs meetings monthly.

The Malaysian government is focused on developing CTS in the areas of blockchain, IoT, 5G, biometrics, intelligent transportation, e-commerce, and smart cities.

Industry Participation in CTS Development: 74

Industry participation in CTS is mature and compares favorably to levels of industry participation in other countries, scoring higher than Vietnam (66), the Philippines (71) and Cambodia (67) and only just behind Indonesia (77). However, there is a significant gap compared to regional leaders Singapore (90) and Australia (90).

Industry participation in global SDOs such as ISO, IEC, ITU-T, and IEEE is one to four times per year. The critical technology standards industry is currently focusing on are IoT, smart cities, blockchain and 5G.

Civil Society Participation in CTS Development: 67

Civil society participation is developing and one of the lowest compared to other countries in the CTSM. Participation as well as the capacity to contribute to CTS development are areas that could be strengthened when it comes to both international and domestic SDOs. The critical technology standards civil society are focusing on are fuel cell tech, blockchain and electromagnetic fields.

Financial Support: 62

The Malaysian government provides relatively limited financial support to participate in SDOs as well as limited support for research for developing CTS. In fact, on this metric Malaysia has one of the lowest scores in the region, doing only better than Cambodia (though Vietnam scored only a point higher than Malaysia). Having said this, all countries in the CTSM scored relatively low in terms of financial support, with the highest score awarded to Australia (74).

Limited financial support appears to be one reason for low overall participation by all Malaysian stakeholders in global SDOs. For instance, industry and civil society reported costs of participating in global SDOs as a significant barrier.

While industry and civil society do fund some research that can support CTS development, this is also limited.

CAPACITY

Awareness: 70

The level of awareness in Malaysia of CTS is relatively high in the region, tying with Singapore and second to Australia (73). That said, levels of CTS awareness in the countries in the CTSM are developing with scope to increase awareness across all countries. In Malaysia, stakeholders are somewhat aware of CTS being developed in global SDOs. The Malaysian government does publish standards and SIRIM convenes seminars on industry standards.[20] However, all stakeholders reported that the information provided by the government on CTS is not always timely or regular. Additionally, awareness in Malaysia of gender implication in CTS development is low.

Expertise: 68

Malaysia scored in the middle of the pack when it comes to stakeholder expertise in developing and implementing CTS, doing better than the Philippines (63) and Vietnam (65) but lower than Australia (75) and Singapore (75). Malaysia's expertise is developing with industry reporting confidence in their levels of expertise to engage in CTS development, and government reporting lower levels of such expertise. Similar divisions emerged when it comes to implementing CTS, with industry reporting higher levels of expertise and government reporting less.

Workforce: 67

Malaysia has relatively developed training and educational programs on CTS but there is room for improvement. For instance, SIRIM runs seminars and conferences on the industry standards they produce, as well as training on compliance, auditing, and awareness of internationally adopted CTS. The workforce is somewhat equipped to assess compliance with CTS, but this is another area where further upskilling may be helpful.

PHILIPPINES COUNTRY PROFILE

Overall score: 69

The Philippine's capacity to develop and implement CTS is developing. Their standards process for critical technologies is government-led but there is no specific strategy for CTS development. The Philippines falls short when it comes to the capacity of its workforce to implement and develop CTS. The CTS Philippines is focusing on are AI, quantum computing, 5G, machine learning, big data, IoT, blockchain, nanotechnology, and cloud computing.

GOVERNANCE

Legislation and Policy: 74

The Philippine's legislation and policy for CTS is mature with some room for improvement. The Philippines scored in the upper end compared to other countries in the CTSM, better than Cambodia (64), Indonesia (65) and Vietnam (66), tied with Malaysia and just below Australia (78) and Singapore (81).

The standardization process is a government led consensus-based approach with participation from industry and civil society. Under the jurisdiction of the Department of Trade and Industry (DTI), the Bureau of Philippine Standards (DTI-BPS) is the peak standards-setting body in the country responsible for CTS development. BPS is a member of global SDOs such as the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC) and regional SDOs such as ASEAN Consultative Committee on Standards and Quality (ACCSQ), the Asia-Pacific Economic Cooperation (APEC) and Pacific Area Standards Congress (PASC). The Department of Information and Communications Technology also play a role in the development of standards, including providing technical expertise, developing standards for government ICT infrastructure, and working with DIT where standards can support international trade.[21]

Standards are drafted by the technical committees (TC) within BPS and there are separate TCs for different kinds of technologies. For instance, the TC for Information Technology (IT) covers IT management, cybersecurity, software, and system engineering etc. BPS also runs a fast-track for standards development where technical committee deliberation can be omitted to make the process quicker.

Domestic regulation allows BPS to adopt international standards, and in the absence of international standards can create Philippines national standards (PNS). When a standard is developed or adopted, it is published and posted in the online portal of BPS.[22]

The country recently laid out Philippines Standardization Strategy 2021-2023, that encourages industry and consumer association involvement in making Philippine national standards (PNS) and adopting international standards to promote local MSMEs and industry's interest in the global market. The strategy acknowledges the low participation of Philippine's industry in global SDOs, and highlights plans to increase participation of Philippine's experts in technical committees in global SDOs such as ISO/IEC.

Government/Industry/Civil Society Coordination: 68

Internal stakeholder coordination is developing but it is better than most of its peers in the CTSM, only scoring lower than Australia (77). Coordination on CTS among government appears most robust, with more room to improve coordination on CTS among industry and civil society.

Government Engagement with Industry/Civil Society: 70

Philippine scored in the upper middle end of the group for government engagement with industry and civil society, tying with Singapore and Indonesia, and only lower than Australia (80). In the new Philippines Standardization Strategy 2021-2023, BPS laid out plans to improve involvement of industry experts in the standardization process to promote local industry growth. The technical committees responsible for CTS development are composed of experts representing academia, consumer groups, trade and industry professionals, and government agencies.

PARTICIPATION

Government Participation in CTS Development: 71

Philippines government participation in CTS development is relatively strong with more robust participation and contribution by the government in global SDOs than in the domestic standardization process.

Government officials participate in global SDOs such

as ISO/IEC, ITU-T and IEEE, one to four times annually, consistent with engagement by many of the other governments in the region, but lower than the regional leaders Australia and Singapore, where government officials participate in global SDOs on a monthly basis on average.

The CTS the government is focusing on are around AI, cybersecurity, ICT, blockchain, and electric and autonomous vehicles.

Industry Participation in CTS Development: 71

Industry participation in CTS is mature, yet comparatively at the lower end of the scale, only scoring higher than Cambodia (67) and Vietnam (66), lower than Malaysia (74) and Indonesia (77) and well behind Australia (90) and Singapore (90).

In contrast to government officials, industry representatives participate more regularly in the domestic standardization process than in global SDOs.

Industry participation in global SDOs such as ISO, IEC, ITU-T, and IEEE is around one to four times per year, consistent with industry participation from other countries in the CTSM, except the regional leaders Australia and Singapore where industry generally attends meeting in those SDOs monthly. These numbers point to room to increase the participation and contribution for industry in CTS development in both domestic and global SDOs.

Civil Society Participation in CTS Development: 71

Civil society participation in the country is at the upper end of the group, tying with Singapore (71) and not far behind Australia (78). Civil society participates more often in in domestic CTS development than in global SDOs.

Civil society participates in global SDOs such as ISO/IEC, and IEEE, one to four times annually, which is consistent with low civil society participation rate in most other countries in the CTSM.

Financial Support: 69

The Philippines scored in the middle of the group when it comes to financial support to facilitate CTS development. While the level of financial support is developing, this is true of financial support across the region.

The government provides some funding for participation of industry and civil society in global SDOs. However, all stakeholders reported not having adequate access to financial resources to participate in global SDOs. The lack of financial support is one of the reasons for the low participation rate global SDOs. Government and industry fund some research that supports CTS development, but there is a lot less funding by civil society for such work.

CAPACITY

Awareness: 63

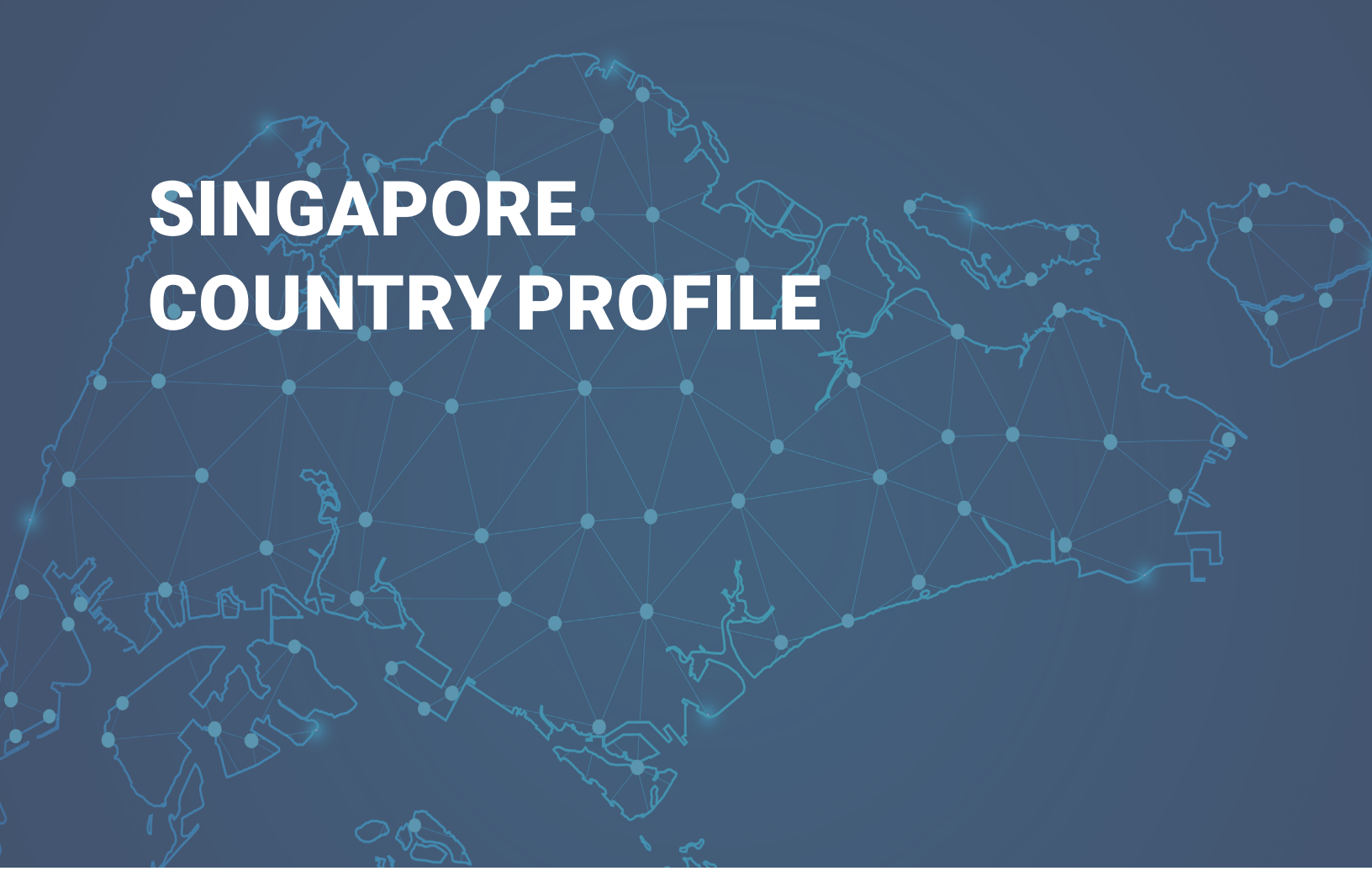
When it comes to awareness of CTS, the Philippines scored one of the lowest in the CTSM, only scoring a point higher than Cambodia (62). Industry and civil society do not receive information from the government on CTS being developed in global SDOs. Additionally, the Philippines is only somewhat aware of the gender implication on CTS.

Expertise: 63

The Philippines also scored the lowest when it comes to having expertise in standardization and implementation of CTS. Industry and government reported having some experience and knowledge of the standardization process depending on the technologies they work with. However, when it comes to implementing CTS, government, industry, and civil society reported having very limited experience.

Workforce: 63

The Philippines is developing training and educational programs on CTS with clear room to strengthen. Along with limited training on CTS, the country has major gaps in the capacity of its workforce to assess compliance with CTS.



SINGAPORE COUNTRY PROFILE

Overall score: 75

Singapore's standardization process is government-supported and consensus-based with strong participation from industry. Singapore has laid out multiple strategies and initiatives to boost adoption of critical technologies in the country and is an active participant in global SDOs. The critical technologies Singapore is focusing on are AI, IoT, smart cities, blockchain, data sharing, cloud computing, and cyber security.

GOVERNANCE

Legislation and Policy: 81

Singapore has advanced legislation and policy for critical standard development and implementation. In fact, it scored the highest in the region in this metric, followed by Australia (78).

Enterprise Singapore, a government agency, is the national standards body responsible for standards development and implementation. Enterprise Singapore administers the standardization process through its industry-led council known as the Singapore Standards Council (SSC) which consists of representatives from industry, professional bodies, trade and consumer associations, academia, and government agencies. SSC is also responsible for promoting standards to help the adoption of international and national standards by local stakeholders. SSC represents Singapore in technical committees in the global SDOs such as ISO/IEC JTC 1 work on CTS.

Infocomm Media Development Authority (IMDA) manages the standardization work of some critical technologies through the Information Technology Standards Committee.[23] IMDA, the agency responsible for Singapore's digital transformation is responsible for the adoption of critical technologies such as AI, big data, cloud computing, cybersecurity, IoT, blockchain, smart cities and 5G among many others.[24] IMDA has laid out different innovation and technology strategies including, Services 4.0 and the Digital Economy Framework for Action.

The standardization process in Singapore is open and comprehensive. The standardization process starts by submitting a proposal for adoption, amendment, or development of standards by the Singapore community, which is open to the public. Standards drafts are also open to public comments prior to approval.

Government/Industry/Civil Society Coordination: 67

Coordination among stakeholders is still developing with some room to improve, scoring lower than Australia (77) and the Philippines (68). Government agencies coordinate effectively with each other on CTS, but not always. IMDA coordinates with other government agencies on CTS through its standard development committees. Industry and civil society also coordinate among each other, but more can be done to strengthen their coordination on CTS.

Government Engagement with Industry/Civil Society: 70

Overall, government's engagement with industry and civil society regarding CTS is developing. IMDA is responsible for coordinating government engagement with both industry and civil society.

Whenever the government develops technology strategies, IMDA publishes them and involves industry in the development and adoption of the technologies. For instance, Advanced Digital Solutions (ADS) helps businesses adopt advanced technologies such as AI, robotics, blockchain, and IoT, and strategies including the Model AI Governance Framework inform industry on the AI governance framework.

PARTICIPATION

Government Participation in CTS Development: 83

Singapore's government participation and contribution in CTS is advanced, with approximately monthly participation by government officials in global SDOs such as ISO/IEC/JTC1, ITU-T, and IEEE. In fact, Singapore scored highest in terms of government participation. The key areas of government focus when it comes to CTS are AI, IoT, smart cities, blockchain, data sharing, and cyber security. The government also helps the development of open-source software to support CTS.

Industry Participation in CTS Development: 90

Although Singapore's standardization process is government-led, there is robust industry participation in CTS development. Industry consistently participates in both domestic and global SDOs such as ISO/IEC/

JTC1, IEEE, and ITU-T. The CTS industry is focused on are AI/machine learning, cloud computing, encryption/ blockchain, quantum, and IoT.

Civil Society Participation in CTS Development: 71

Civil society participation in CTS development is not as vigorous as government or industry participation. Having said that, Singapore still scored in the upper end of this metric, only behind Australia (78). Civil society participates in both domestic, and global SDOs. Yet, the frequency of participation and quality of contribution can be improved.

Financial Support: 69

Singapore's financial support for CTS is developing, scoring lower than Australia (74) and Indonesia (72) and tying with the Philippines. Enterprise Singapore, through its Enterprise Development Grant, provides some funding to support standards adoption by businesses as well as certifications and training.[25]

In terms of funding for research that supports CTS development, all stakeholders (government, industry, and civil society) provide financial resources but there is room to strengthen funding for CTS development. There is some research that helps develop critical technologies, such as the National University of Singapore (NUS) funds different research programs with their initiative called Smart Nation to help develop critical technologies such as AI, cybersecurity, data science, and quantum computing.

CAPACITY

Awareness: 70

The level of awareness on CTS development in Singapore is developing with room for improvement. That being said, the levels of awareness of CTS in the CTSM are developing with the scope to increase awareness across all countries. Government and industry have general awareness of CTS being developed in global SDOs, depending on the type of critical technology. Government informs industry and civil society on the CTS developed in global SDOs; however, the information is not always timely. CTS that are developed are posted online on the Singapore Standards website.[26]

Additionally, there is some awareness in Singapore of gender implications in CTS development.

Expertise: 75

Singapore has a range of expertise when it comes to developing and implementing CTS. Industry and government reported more confidence in their level of expertise in CTS whereas the civil society reported slightly lower confidence in their expertise. That said, Singapore's overall levels of expertise is significantly better than other countries in the CTSM, tying with Australia.

Workforce:70

Singapore has a reasonably skilled workforce in the country with room for improvement, although it has scored higher in this metric compared to other countries in the region, second only to Australia (78).

IMDA has training programs and certifications to help the workforce comply with critical technology standards and has initiatives to train the workforce in regulation in ICT.[27]

VIETNAM COUNTRY PROFILE

Overall score: 64

Vietnam's standardization process for developing CTS is government-led. The governance framework for CTS development is under review and Vietnam aims to publish a National Standardization Strategy early next year.

Participation by industry and civil society in CTS is developing. Vietnam also falls short when it comes to participation of stakeholders in global SDOs. Vietnam's capacity to develop CTS as well as assess compliance with CTS is an area that could be strengthened, and training programs for CTS are lacking. The critical technologies Vietnam is focused on are AI, IoT, quantum computing, cloud, blockchain, cloud computing, and cyber-security.

GOVERNANCE

Legislation and Policy: 66

Vietnam's legislation and policy is developing. It scored at the lower end, only doing better slightly than Indonesia (65) and Cambodia (64).

Vietnam's standardization process is government led. The Directorate for Standard, Metrology, and Quality (STAMEQ) is the peak standard body under the Ministry of Science and Technology (MOST). STAMEQ is a member of global SDOs such as the International Organization for Standardization (ISO) and International Electrotechnical Commission (IEC), and regional SDOs such as Pacific Regional Standards Conference (PASC) and ASEAN Advisory Committee on Standards and Quality (ACCSQ).

Relevant ministries are responsible for developing, adopting, and drafting national technical regulations (QCVN) for areas under their state management authority.

MOST can also develop national standards (TCVN) including CTS if standards are needed and haven't been proposed by other ministries. Standards are developed by line ministries working through technical committees that include representation from relevant regulators, industry, academia, associations, and consumers. MOST is also responsible for approving proposed CTS.

Vietnam does not have a specific strategy for critical technologies, similar to most other countries in the CTSM. It has, instead various technology strategies, such as the National Strategy on R&D, an AI strategy led by MOST, and a strategy on smart cities—the Ho Chi Minh Smart City. However, Vietnam's approach to CTS development is under review and Vietnam aims to publish a National Standardization Strategy early next year.

Government/Industry/Civil Society Coordination: 60

Coordination among government, industry and civil society in Vietnam is one of the lowest in the CTSM, improving only on Cambodia's score (53). Government coordination is not effective, and while there is some coordination among industry and among civil society on CTS, it is often not effective in terms of producing common positions.

Government Engagement with Industry/Civil Society: 66

The country has one of the lowest scores in the CTSM when it comes to government engagement with industry and civil society on CTS, tying with Malaysia and Cambodia. Government engagement with industry and civil society on CTS is occasional and often seen as ineffective when it comes to supporting CTS development and implementation.

PARTICIPATION

Government Participation in CTS Development: 70

Vietnam government officials participate and contribute to the development of domestic CTS as well as CTS developed in global SDOs. However, the government is focused on domestic standard development rather than standards in global SDOs.

Compared with other countries in the CTSM, Vietnam scored in the middle of the range for government participation in global SDOs, doing better than Cambodia (67) and Indonesia (67), but well below regional leaders Australia (76) and Singapore (83).

Vietnam government officials participate only one to four times a year in global SDOs such as ISO, IEC, IEEE, ITU-T, and CODEX

The critical technology Vietnam's government is focusing on are AI, cloud computing, IoT, cyber security, blockchain, and 3D printing.

Industry Participation in CTS Development: 66

Industry participation in CTS is still developing and scored the lowest in the CTSM. The relatively low level of industry participation in CTS development is largely due to very low participation by industry in global SDOs (and relatively higher participation in domestic

CTS development)

Industry participates in global SDOs such as ISO one to four times a year and the critical technologies industry is focused on are AI, IoT, cloud computing, blockchain, cybersecurity and 3D printing

Civil Society Participation in CTS Development: 62

Participation by Vietnam's civil society in CTS development is also limited. In this regard, Vietnam scored at the lower end of countries in the region, scoring only higher than Cambodia (58). There's little to no participation of civil society in global SDOs, and participation by civil society in the domestic standardization processes is also low.

The critical technology civil society is focusing on are cyber security, cloud computing, AI, and IoT.

Financial Support: 62

The Vietnamese government provides limited financial support to participate in global SDOs. Vietnam scored at the lower end in this metric only scoring higher than Cambodia (58) and tying with Indonesia at 62. Having said this, all countries in this CTSM scored relatively low when it comes to financial support.

Limited financial support is one of the main reasons for low overall participation by all Vietnamese stakeholders in global SDOs. Industry and civil society reported costs of travel to participate in the global SDOs as a significant barrier. The government encourages participation of industry/ civil society in global SDOs but does not provide the financial support for participation.

While government, and industry do fund some research that can support CTS development, there is very little funding from civil society.

CAPACITY

Awareness: 65

Overall level of awareness of CTS in Vietnam is in the middle of the group, higher than in the Philippines (63) and Cambodia (62) and tying with Indonesia. Across the region, the awareness level of CTS is developing, with Australia (73) leading, followed by Malaysia (70) and Singapore (70).

The government could provide more accurate and detailed information on CTS being produced in global SDOs. Even when industry/civil society get information from the government on CTS activity in global SDOs, it is often not timely. There is also some awareness of the gender implications of CTS.

Expertise: 65

The level of expertise in Vietnam when it comes to CTS development and implementation is developing, scoring in the lower end of the CTSM, higher than the Philippines (63) but lower than Cambodia (68) and Malaysia (68). Overall, stakeholders have some knowledge of the standardization process. While government and industry have some experience in implementing CTS developed in global SDOs, civil society has little to no experience implementing CTS.

Workforce: 53

The level of skilled workforce able to develop and implement CTS is underdeveloped in Vietnam, scoring the lowest in the region. Vietnam does not have workforce training programs on CTS development, implementation or on how to assess compliance with CTS.

END NOTES

1 Critical Technology Policy Coordination Office, Prime Minister and Cabinet. https://www.pmc.gov.au/domestic-policy/critical-technologies-policy-coordination-office

2 Subcommittee on Security Export Control Policy, Trade Committee, Industrial Structure Council, The Ministry of Economy, Trade and Industry. https://www.meti.go.jp/english/policy/external_economy/trade_control/pdf/191008a.pdf

3 U.S. White House 2022. https://www.whitehousegov/wp-content/uploads/2022/02/02-2022-Critical-and-Emerging-Technologies-List-Update.pdf

4 AIA Article 11. https://artificialintelligenceact.eu/

5 AIA Article 40. https://artificialintelligenceact.eu/

6 IEEE, P7000. https://sagroups.ieee.org/7000/

7 2021 G7 Leaders Communique Para 33, June 13, 2021. https://www.consilium.europa.eu/en/press/press-releases/2021/06/13/2021-g7-leaders-communique/

8 IEC, ISO, ITU "Call to act at Riyad International Standards Summit", November 4, 2020. https://bit.ly/3yawuPd

9 Tim Buthe and Walter Mattli, "Typology of Global Regulation in The New Global Rulers: The Privatization of Regulation in the World Economy (Princeton University Press 2011), p. 30. https://press.princeton.edu/books/hardcover/9780691144795/the-new-global-rulers

10 ITU-T Study Groups (Study Period 2017-2021) https://www.itu.int/en/ITU-T/studygroups/2017-2020/Pages/default.aspx

11 ITU-T, Membership Categories, https://www.itu.int/en/ITU-T/membership/Pages/Rights.aspx

12 Department of Foreign Affairs and Trade, Digital Trade Strategy, April 2022. https://www.dfat.gov.au/trade/services-and-digital-trade/e-commerce-and-digital-trade/digital-trade-strategy

13 Information Technology Professionals. https://www.itpa.org.au/

14 Iswara, Anthony. "Indonesia sets sights on artificial intelligence in new national strategy." The Jakarta Post. https://www.thejakartapost.com/news/2020/08/13/indonesia-sets-sights-on-artificial-intelligence-in-new-national-strategy.html.

15 Id-SIRTII/CC, BSSN. https://idsirtii.or.id/en/bssn_page.html

16 Id-SIRTII/CC, BSSN. https://idsirtii.or.id/en/bssn_page.html;

17 "Committee on Technical Barriers to Trade", World Trade Organization, June 5, 2012. https://bit.ly/3C4Pj8z

18 Asia Pacific Economic Cooperation Sub-Committee on Standards and Conformance (APEC-SCSC). https://www.apec.org/Groups/Committee-on-Trade-and-Investment/Sub-Committee-on-Standards-and-Conformance

19 "MS Development Process", Department of Standards Malaysia. https://www.jsm.gov.my/ms-development-process#.YpeMv6jMI2w

20 Training Planner 2022, Sirim STS. https://www.sirimsts.my/phocadownload/Downloads/Course%20Content/ATP2022.pdf

21 Mandate Power Function, Department of Infor-

mation and Communications Technology. https://dict.gov.ph/about-us/our-mandate/

22 Bureau of Philippine Standards, Standards and Conformance Portal. https://bit.ly/3R8Yrxd

23 Standards and Classification, Infocomm Media Development Authority. https://www.imda.gov.sg/regulations-and-licensing-listing/content-standards-and-classification/standards-and-classification

24 "Accelerating Singapore's Digital Economy", Infocomm Media Development Authority, 2021. https://www.imda.gov.sg/annualreportfy20/index.html#p=32

25 Standard Adoption, Enterprise Singapore. https://www.enterprisesg.gov.sg/financial-assistance/grants/for-local-companies/enterprise-development-grant/market-access/standards-adoption

26 "Standards for Industry 4.0", Singapore Standards Shop. https://www.singaporestandardseshop.sg/StdResources/IndustrySolution/c4ee4613-bc26-4a4d-b5b2-cc9336d1cb23

27 Compliance and Certification, Infocomm Media Development Authority. https://www.imda.gov.sg/regulations-and-licensing-listing/ict-standards-and-quality-of-service/IT-Standards-and-Frameworks/Compliance-and-Certification;

ANNEX

ANNEX 1

CTSM Methodology

The Critical Technology Standards Metric (CTSM) assesses the capacity of a country to develop and implement CTS. This metric assesses the proficiency in critical technology standards across three key area: Governance, Participation and Capacity. Governance comprises three categories: 1. Legislation & Policy, 2. Government/ Industry/Civil Society Coordination, and 3. Government Engagement with Industry/Civil Society. Participation is made up of four categories: 1. Government Participation in CTS Development, 2. Industry Participation in CTS Development, 3. Civil Society Participation in CTS Development and 4. Financial Support. Capacity is also made up of three categories: 1. Awareness, 2. Expertise, and 3. Workforce.

The CTSM is based on a questionnaire comprised of 55 questions. The allocation of questions across the sub-categories, their scores and weighting are in Annex 2. The full list of questions is in Annex 3. The questionnaire was developed using internal expertise and refined based on input from a senior advisory group of CTS experts from government, industry, and standards bodies. The answers were individually weighted according to their importance level (1.0 for very important, .75 for important, and 0.5 for somewhat important). This weighting was also refined based on input from our senior advisory group. The weights accorded to each question is in Annex 2.

To get a score for each question, each response was multiplied by its respective weights. For each category, a weighted average was calculated, by adding the individual scores, taking an average for the category and then converting to a score out of 100. The overall score for each country is the weighted average of all the five scores in the metric. Below is the formula used to get the weighted average score.

$$\bar{W} = \frac{\sum_{i=1}^{n} X_i w_i}{\sum_{i=1}^{n} w_i} \times 10$$

$\bar{W}$ = weighted average score out of 100, X_i= individual scores of each question out of 10, w_i=individual weights assigned to each question.

ANNEX 2. TABLE 1

Theme	Category	Question	Weights	Australia	Cambodia	Indonesia	Malaysia	Philippines	Singapore	Vietnam
Governance	Legislation & Policy	q1	1	9	6	7	7	7	9	7
		q2	1	7	5	7	7	7	9	5
		q3	1	9	7	6	7	8	9	7
		q4	0.75	7	7	7	8	7	7	7
		q5	1	7	5	6	7	7	7	6
		q6	0.75	7	5	5	7	7	7	5
		q7	1	9	9	7	8	9	9	9
		q8	0.75	7	7	6	9	7	8	7
		q9	0.75	7	7	7	7	7	7	6
	Government/ Industry/ Civil Society	q10	0.75	9	5	5	5	5	5	5
		q11	0.75	7	7	6	6	7	7	7
		q12	0.75	8	5	7	7	7	7	7
		q13	0.75	8	5	7	7	7	7	5
		q14	0.75	7	5	7	7	7	7	7
		q15	0.75	7	5	7	7	8	7	5
	Government Engagement	q16	1	9	6	7	7	7	7	7
		q17	1	7	7	7	6	7	7	6
		q18	0.75	8	7	7	7	7	7	7

ANNEX 2. TABLE 2

Theme	Category	Question	Weights	Australia	Cambodia	Indonesia	Malaysia	Philippines	Singapore	Vietnam
Participation	Government Participation in CTS Development	q19	1	8	8	7	8	7	8	8
		q20	0.75	7	7	7	8	7	8	8
		q21	0.75	7	7	7	7	8	8	7
		q22	0.75	7	6	7	8	8	8	7
		q23	0.75	9	6	6	6	6	9	6
		q24	0.5	7	5	6	5	6	9	5
	Industry Participation in CTS Development	q25	1	9	7	8	8	8	9	7
		q26	0.75	9	8	8	8	7	9	7
		q27	0.75	9	7	8	8	7	9	6
		q28	0.75	9	6	8	7	7	9	6
		q29	0.75	9	5	6	6	6	9	6
		q30	0.5	9	7	8	7	7	9	8
	Civil Society Participation in CTS Development	q31	1	8	6	7	7	8	7	7
		q32	0.75	8	6	7	7	7	7	7
		q33	0.75	8	6	7	7	7	7	5
		q34	0.75	7	5	7	6	7	7	5
		q35	0.75	8	6	6	6	6	7	6
		q36	0.5	8	6	8	7	7	8	7
	Financial Support	q37	0.75	7	7	6	5	7	7	6
		q38	1	7	5	6	6	7	7	5
		q39	0.75	9	5	9	7	9	7	7
		q40	0.75	7	5	8	6	6	6	5
		q41	0.75	7	6	7	7	7	7	7
		q42	0.75	7	5	8	7	7	7	7
		q43	0.75	7	6	7	6	5	7	6
		q44	0.75	8	6	7	6	7	7	7
Capacity	Awareness	q45	1	8	6	7	7	7	7	6
		q46	0.75	7	6	6	7	5	7	6
		q47	0.75	7	6	6	7	5	7	7
		q48	0.75	7	7	7	7	8	7	7
	Expertise	q49	1	7	7	7	7	7	7	7
		q50	0.75	7	6	7	6	6	8	7
		q51	0.75	9	7	7	7	6	8	7
		q52	0.75	7	7	7	7	6	7	5
	Workforce	q53	0.75	7	6	6	7	6	7	5
		q54	0.75	9	5	6	7	7	7	6
		q55	0.75	7	6	6	6	6	7	5

ANNEX 3. TABLE 1

CTSM Questions List: Governance

Governance
Legislation and Policy
1. Is there a government strategy, policy or law regarding the development and use of international standards?
2. Is there a separate government strategy, policy or law that applies to the government's development and use of international critical technology standards?
3. Is there a requirement that domestic laws, regulation, and standards, where relevant be based on international critical technology standards (CTS)?
4. Does the strategy, policy, or law with respect to critical technology standards apply to industry/private sector?
5. Is there a requirement for industry to base domestic critical technology standards on international critical technology standards?
6. Is there a strategy, policy or law that applies to government and/or industry participation in standards consortia, i.e., W4F, IETF, OASIS?
7. Does your government identify international CTS as standards developed consistent with the Decision of the WTO TBT Committee on Principles for the Development of International Standards, Guides and Recommendations with Relation to Article 2, 5 and Annex 4 of the Agreement (G/TBT/2/Rev.24, p. 62), such as requiring that the standards making process by transparent, open to participation and that decisions are reached by consensus.
8. Is the strategy, policy, or law neutral as to which standard development organizations (SDO) produces the critical technology standards?
9. Is there a single government agency/body responsible for developing critical technology standards (CTS)?
Government/Industry/ Civil Society Coordination
10. Is there an industry body solely responsible for critical technology standards (CTS)?
11. Is there effective coordination among government agencies on critical technology standards policy?
12. Does industry coordinate approaches to critical technology standards among each other?
13. Is the coordination between industry effective?
14. Does civil society/ academia coordinate approaches to critical technology standards among each other?
15. Is the coordination between (civil society/academia) effective?
Government Engagement with Industry/Civil Society
16. When the government develops its position on international CTS, does the government engage with and seek input from industry and civil society?
17. Is there a strategy, policy or law that requires government coordination/engagement with stakeholders such as industry and civil society, regarding proposed critical technology standards?
18. Does government coordination/engagement with industry/ civil society on international CTS produce outcomes (i.e., which facilitates CTS development and implementation).

ANNEX 3. TABLE 2

CTSM questions list: participation

Participation
Government Participation in CTS Development
19. Do relevant government officials participate in meetings in domestic CTS development?
20. Do relevant government officials contribute to domestic CTS development? (Contribute means more than just attending, and could include making proposals, chairing meetings etc)
21. Do relevant government officials participate in meetings in CTS development with global standards development organizations?
22. Do relevant government officials contribute to international CTS development in global SDOs? (Contribute means more than just attending, and could include making proposals, chairing meetings etc)
23. How often does a representative from government attend meetings of global SDOs on CTS?
24. Does government contribute to the development of open-source software in support of CTS development?
Industry Participation in CTS Development
25. Does industry participate in meetings in domestic CTS development?
26. Does industry contribute to domestic CTS development? (Contribute means more than just attending, and could include making proposals, chairing meetings etc.)
27. Does industry participate in meetings in CTS development with global standards development organizations?
28. Does industry contribute to international CTS development in global SDOs? (Contribute means more than just attending, and could include making proposals, chairing meetings etc)
29. How often does a representative from industry attend meetings of global SDOs on CTS?
30. Does industry contribute to the development of open-source software in support of CTS development?
Civil Society Participation in CTS Development
31. Does civil society participate in meetings in domestic CTS development?
32. Does civil society contribute to domestic CTS development? (Contribute means more than just attending, and could include making proposals, chairing meetings etc.)
33. Does civil society participate in meetings in CTS development with global standards development organizations?
34. Does civil society contribute to international CTS development in global SDOs?
35. How often does a representative from civil society attend meetings of global SDOs on CTS?
36. Does civil society contribute to the development of open-source software in support of CTS development?
Financial Support
37. Do you have the financial resources to participate in SDOs developing CTS?
38. Does the government finance and/or support participation in global standard development organizations by industry/civil society/academia?
39. Is government financial support not tied to for leadership roles in SDOs?
40. Is government financial support for participation in SDOs sufficient?
41. Does the government fund research that can lead to CTS development?
42. Does industry fund research that can lead to CTS development?
43. Does civil society fund research that can lead to CTS development?
44. Is the fee for industry/civil society participation in CTS meetings in global SDOs not a barrier to participation?

ANNEX 3. TABLE 3

CTSM questions list: capacity

Capacity
Awareness
45. Are you aware of the range of CTS being developed in SDOs that matter to you (govt, industry, civil society)?
46. Do you (industry/civil society) get information from the government on international CTS development? e.g., which SDOs are developing which CTS.
47. If you (industry, CS) get information from the government on international CTS development, is it useful and timely?
48. Are you aware of gender implications in setting CTS?
Expertise
49. Do you have the knowledge/expertise of the technology and the standardization process to engage in CTS development?
50. Does government have experience implementing CTS developed in global SDOs?
51. Does industry have experience implementing CTS developed in global SDOs?
52. Does civil society have experience implementing CTS developed in global SDOs?
Workforce
53. Is there training/education program in your country on CTS development?
54. Does the country have the skilled workforce that can assess compliance with CTS?
55. Is the government training workers to assess compliance with CTS?

ANNEX 4. TABLE 1

		Governance			Participation				Capacity		
Country	total score weighted average	Legislation and Policy	Gov/Industry/Civil Society Coordination	Gov Engagement with Industry/ Civil Society	Gov Participation in CTS Development	Industry Participation in CTS Development	Civil Society Participation in CTS Development	Financial Support	Awareness	Expertise	Workforce
AUS	78	78	77	80	76	90	78	74	73	75	77
KHM	62	64	53	66	67	65	58	56	62	68	57
IDN	68	65	65	70	67	77	69	72	65	70	60
MYS	69	74	65	66	72	74	67	62	70	68	67
PHL	69	74	68	70	71	71	71	69	63	63	63
SGP	75	81	67	70	83	90	71	69	70	75	70
VNM	64	66	60	66	70	66	62	62	65	65	53

50-60: Underdeveloped
61-70: Developing
71-80: Mature
81-100: Advanced

BROOKINGS

1775 Massachusetts Ave NW,
Washington, DC 20036
(202) 797-6000
www.brookings.edu