Standardising Standard Setting for 6G

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CUTS International
D-217, Bhaskar Marg, Bani Park, Jaipur 302016, India
Tel: +91.141.2282821, Fax: +91.141.2282485
Email: cuts1@cuts.org, Web site: www.cuts-international.org

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Contents

Abbreviations

ACSC:	Australian Cyber Security Centre
AICCTP:	Australia-India Cyber and Critical Technology Partnership
ARPI:	Australian Risk Policy Institute
CDMA:	Code-Division Multiple Access
C-DoT:	Centre of Development of Telematics
CRs:	Change Requests
DFAT:	Department of Foreign Affairs and Trade
DoT:	Department of Telecommunications
eMBB:	enhanced Mobile Broadband
EPC:	Evolved Packet Core network
eURLLC:	enhanced Ultra-Reliable, Low-Latency Communication
FCC:	Federal Communications Commission
FRAND:	Fair Reasonable, and Non-Discriminatory
GNSS:	Global Navigation Satellite System
GSM:	Global System for Mobile Communications
HTML:	HyperText Markup Language
IAB:	Integrated Access and Backhaul
IIITB:	International Institute of Information Technology, Bangalore
IIoT:	Industrial Internet of Things
IoT:	Internet of Things
IoWT:	Internet of Wearable Things
IPEF:	Indo-Pacific Economic Framework
IPRs:	Intellectual Property Rights
ISO:	International Organisation for Standardisation
ITS:	Intelligent transportation systems
KPIs:	Key Performance Indicators
PDF:	Portable Document Format

R&D: Research & Development

SCs: Subcommittees

SDOs: Standard Development Organisations
SEPs: Standard Essential Patents

TCs: Technical Committees
TD-SCDMA: Time Division Synchronous Code Division Multiple Access

URLCC: Ultra-Reliable Low-Latency Communications
UWB: Ultra-Wideband

V2X: Vehicle-to-everything

WRC: World Radiocommunication Conference

Executive Summary

As the economy and society become increasingly digitised, wireless networks are serving as the critical infrastructure enabling several emerging technologies including machine-to-machine and machine-to-person communication. The structure of society is moving towards a future where everything is super-connected and it is poised to transform how we live, work, and interact with each other.

Standards play a crucial role all around us because they enable devices to interact with each other, allowing us to connect to mobile networks, and facilitating the exchange of information. Opening up and incorporating standards worldwide promotes international trade compared to country-specific standards. Standards have also played an increasingly crucial role in enabling societies to harness the opportunities presented by digital technologies such as IoT.

Standards in communication specifications have made devices and services affordable to many at the same time providing complete interoperability. Standards bring out innovations in communication technologies and, at the same provide scale advantages to equipment and device manufacturers. International SDOs such as 3GPP and IEEE along with organisations such as the ITU have promoted standardisation activities in a well-orchestrated multi-stakeholder collaborative model of governance and processes. Further opening up and incorporating standards worldwide promotes international trade compared to individual country-specific standards. Currently, while there is limited information available about the standards of 6G, it is estimated that the international standardisation bodies will sort out the standards for 6G by the year 2030.

In the telecommunications industry, we have seen the evolution of open voluntary cooperative standards that are developed or ratified through a consensus-driven process. These are driven through the Standard Development Organisation (SDO), which follows an open and transparent Intellectual Property Rights (IPRs) policy. Most standards in telecom are Standard Essential Patents (SEPs) that are implemented by SDOs using Fair Reasonable, and Non-Discriminatory (FRAND) terms, with or without royalties/fees. The path towards SEPs has brought down the royalty costs of patents at the same time providing reasonable return on the Research & Development expenditure the firms incur on the development of new technologies. The 6G standards development process also is expected to take this path for the affordable adoption of 6G technologies.

While standards are typically seen through technical and economic lenses, they inherently possess a political dimension. The political aspect is particularly visible due to their capacity to contribute to specific policy objectives, ranging from facilitating innovation and safeguarding consumer rights to ensuring national security. Against this backdrop of escalating technological competition among nations, standards are increasingly at the centre of attention within the geopolitical landscape. Therefore, the efficient operation of standards-setting organisations and the developmental process of standards is indispensable for the successful transition of R&D efforts into an innovative and competitive wireless ecosystem.

In the Indo-Pacific region, India and Australia have a larger role to play in actively promoting and engaging in the standardisation process, given the geopolitical effects on the telecom equipment supply chain. Further, as partners in the ITU Region-3, India and Australia have a larger role to play in the standardisation process for 6G. It is also important for India and Australia to play a leading role in the radio spectrum harmonisation process specifically, the TeraHertz spectrum for 6G services and the spectrum for the Low Earth Orbit Satellite-based 6G services. In this chapter, we provide updates on the standardisation activities for 6G and the key role to be played by India and Australia in the standard-setting process for 6G.

The report aims to promote standards that are open and consensus-driven based on rules, protocols, and technical specifications which govern how devices and networks communicate with each other. To this end, the report will deconstruct the standardisation process for 6G which is complex and involves different stakeholders with competing interests and needs. The report is for relevant stakeholders such as policymakers, equipment manufacturers, mobile network operators and technologists to build consensus and develop global standards that are both interoperable and able to meet the requirements of future telecommunications applications.

Key Findings

- Given the critical stage of the global telecommunication ecosystem and the onset of pre-standard 6G trials, policymakers, market regulators, and industry stakeholders must collaborate to chart a unified path forward. India and Australia can benefit from enhanced collaboration among its standards organisations, industry, and academic institutions.

- Australia and India need to cultivate a more comprehensive understanding of the interrelated matters involving standards, digital trade, and internet governance. This should include capacity building of domestic firms and increasing awareness including on SEP, and IP.

- Active participation in international standard development organisations like 3GPP and ITU-R is essential. This engagement plays an important role in guiding new entrants, helping them identify specific research gaps in technology development and focusing their R&D efforts on addressing these gaps. Additionally, build engagement with regional standards organisations within and across the Indo-Pacific to leverage support from different standard-setting bodies.

- Australia and India should collaborate to enhance the exchange of statistical data, and trade, improve interoperability, and create a business-friendly environment. This joint effort can significantly contribute to innovation and optimisation in the global telecommunications market, ensuring its safety, resilience, and competitiveness. With growing geopolitical tensions, establishing trusted partnerships to ensure the secure supply of goods and materials through resilient supply chains would be crucial.

About the Project

The project, titled "Ethical 6G: Identifying Elements of an Ethical Framework for 6G and Creating Opportunities for India and Australia," is a collaborative effort between CUTS International, the Australian Risk Policy Institute (ARPI), and the International Institute of Information Technology, Bangalore (IIITB). This initiative is supported by the Department of Foreign Affairs and Trade (DFAT), Australia under the Australia-India Cyber and Critical Technology Partnership (AICCTP) Grant.

Recognising the critical importance of cyber technologies and their growing influence on international relations, the AICCTP was formed with the primary aim of fostering an open, secure, free, accessible, stable, peaceful, and interoperable cyberspace. Emerging technologies like Artificial Intelligence, next-generation telecommunications, the Internet of Things, quantum computing, synthetic biology, blockchain, and big data, are central to this partnership.

The project is grounded in the comprehensive strategic partnership between India and Australia, which was signed in June 2020. It focuses on fostering cooperation between both countries, particularly in the context of developing next-generation networks such as 5G and 6G, with an emphasis on security, resilience, and diverse technology supply chains. The project aims to identify elements for an ethical framework for future 6G technology, create an enabling environment for Indian and Australian institutions to participate in the 6G standard-making process, and develop opportunities for firms in both nations to invest in and promote 6G in the Indo-Pacific region.

The research outputs are divided into four components:

1. Understanding 6G: Development and Challenges
2. Strategic Opportunities for Australia and India from 6G
3. Standardising Standard Setting for 6G
4. Identifying Elements of an Ethical Framework for 6G.

Methodology

- Detailed review and analysis of research papers, industry reports and government regulations and policies.
- Exhaustive structured interviews with experts in the Telecom Industry (telcos, Network Equipment Manufacturers), Academia, Government, Standard Setting Organisations (TSDSI), and Industry organisations (COAI).

Chapter 1
Introduction

The sixth-generation telecommunications (6G) evolution is anticipated to solidify the long-awaited era of the Internet of Things and the Internet of Sensing. In 6G, every physical object, not just everyone, will have the ability to connect and communicate continuously. Powered by terrestrial base stations and low-earth orbit satellites, it will synchronise driverless cars with smart city environments, fostering new networking and communication innovations. Technically, 6G is expected to extensively utilise millimetre waves and higher terahertz frequency bands (100GHz-10THz), surpassing the highest frequency band of 24GHz-40GHz in 5G. Experts anticipate superior coverage, costs, and opportunities for network intelligence in 6G compared to 5G. To realise the potential of 6G, open and globally collaborative development of standards would be crucial.

Standards in communication specifications have made devices and services affordable to many at the same time providing interoperability. Standards bring out innovations in communication technologies and, at the same provide scale advantages to equipment and device manufacturers. While we are in the very early stages of the 6G standardisation process, organisations such as ITU have set the ball rolling in developing unified global standards for 6G. We have identified some of the main constructs of standardisation that are needed in 6G in this research report with a view that we can develop an ecosystem for 6G products and services which can benefit the economy and society. Therefore, ***Chapter 1*** will provide an overview of the 6G standards and processes and why they matter now more than ever.

Further, establishing digital standards occurs across various organisations and forums, spanning national, regional, and global levels. The international telecom standardisation ecosystem is notably complex, characterised by distinct membership structures, rules, and procedures. This complexity poses challenges for the organisations involved, policymakers and industries participating in this collaborative effort. ***Chapter 2*** of the report provides an introduction to various aspects of standardisation including process, standard-setting organisations and challenges associated with it. The chapter will delve into the key motivations and threats of different standard-setting processes, taking examples of the Fifth Generation (5G) mobile communication technology.

Starting in 2016, 3GPP has undertaken substantial efforts in formulating 5G standards. The initial comprehensive set of 5G standards, known as Release 15, and its subsequent iteration, Release 16, have been incorporated into the IMT-2020 radio interface specifications endorsed by ITU-R in February 2021. Release 17 is dedicated to consolidating and enhancing the concepts and functionalities introduced in the previous Releases while introducing a small number of brand-new features. Currently, there is ongoing development for Release 18, with the anticipated finalisation scheduled for 2024. ***Chapter 3*** of the paper focuses on the standardisation activities introduced in 5G and underscores the learning opportunities it provides to develop ubiquitous standards for 6G.

Furthermore, technical standards have gone beyond the scope of forums where specialists discuss and establish specifications to facilitate development and international trade. They now serve as a strategic instrument to establish dominance and play a crucial role in foreign and trade policy. ***Chapter 4*** focuses on the role of India and Australia in contributing to an open and secure cyberspace in the Indo-Pacific region, in the context of 6G. This chapter will also attempt to understand the learnings from the 5G standards-setting process and how Australia and India can contribute to developing 6G standards. In addition, the chapter will touch upon opportunities vis-à-vis standardisation of 6G, and prospects for India & Australia, especially from a geopolitical perspective.

There will be virtualisation and market convergence at the levels of devices, networks, and platforms. The economic impact of 6G is predicted to be unparalleled, serving as the basis for a worldwide innovation ecosystem that will introduce disruptive and innovative products, thus improving global efficiency and productivity. **Chapter 5** would also provide the way forward to develop an optimal standardisation framework and opportunities for collaboration between Australia and India. This would aid in advocating for a model which promotes innovation, competition, and interoperability, thereby ensuring efficient global development and deployment of the 6G technology.

Chapter 2

Overview of Standard-Setting Processes

2.1 Why are Standards Important?

The advancement of telecommunication networks is central to social and economic development and plays an important role in making the Internet of Things (IoT) possible. However, for this highly connected communication system to reach its full potential, there is a need for a global standardised foundation for devices to connect seamlessly. In today's world where production of a product is no longer confined to one company. Instead, it involves the coordinated efforts of multiple firms globally which allows each firm to focus on what they do best, without wasting resources on less efficient attempts in other steps of the production process.

Historically, digital standards focused on developing technology and devices but the current trend is moving towards standards that facilitate the connection of devices, such as mobile phones and the IoT, as well as the connection of people to digital devices and services. This specialisation was facilitated by a shift from manufacturing-based economies to more knowledge-based ones in the developed world. Consequently, what used to be produced by one large integrated firm is now often the combined output of many specialised, smaller firms working together in the ICT sector.[1]

Therefore, standards have gained crucial importance across domains, including quality management, aviation, health and food safety, labour conditions, and environmental considerations. Standards are widely accepted frameworks that offer technical specifications or outline processes and serve as a guiding force on how to perform tasks which encourages a coordinated approach. Beyond framing product development, standards also strive to guarantee the transparent and safe implementation of diverse technologies.[2] As defined by the International Organisation for Standardisation (ISO):

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1 Layne-Farrar, Anne, Business models and the standard setting process, SSRN (2010), available at https://papers.ssrn.com/sol3/papers.cfm?abstract_id=1718065

2 Geradin, Damien and Layne Farrar, Anne, The Logic and Limits of Ex Ante Competition in A Standard-Setting Environment, Competition Policy International, available at https://www.competitionpolicyinternational.com/assets/0d358061e11f2708ad9d62634c6c40ad/GeradinLayne.pdf

> A standard is a document that provides requirements, specifications, guidelines or characteristics that can be used consistently to ensure that materials, products, processes and services are fit for their purpose.[3]

It serves as a foundation for industry players to develop new technologies and improve existing practices. Standards not only grant access to well-established markets but also foster innovation, and enhance awareness of technical developments. From a technical standpoint, standards serve as a common language that promotes interoperability, enabling different technologies to interact seamlessly. They ensure that devices and applications adhere to the same rules and communication protocols, facilitating the exchange of data in compatible formats.[4] Beyond interoperability, standards also focus on ensuring quality of service and quality of experience.

Economically, standards play a crucial role in fostering competitiveness. Global standards facilitate trade by providing companies access to new markets and preventing fragmentation between trade partners. This is essential not only for major players but also for smaller economies, ensuring that well-functioning global standards enable their firms to export globally under fair competition terms.[5] In Germany, it is estimated to save the economy US$17bn annually, while in France, the average gains are around US$5bn per year. In the UK, approximately 28.4 percent of the annual GDP growth, equivalent to US$bn, is attributed to standards.[6]

2.2. Process of Standardisation

- **Pre-standard phase**

  The setting of requirements is usually elaborated in the pre-standardisation phase, often using white papers, providing the vision of the industry and associations. In this phase, one should take into account all the use cases such as industry 4.0, augmented reality, autonomous transportation, and eHealth, and analyse and categorise them into different classes. For example, the use cases are classified into one of the following: eMBB (enhanced Mobile Broadband), and Ultra-Reliable Low-Latency Communications (URLLC). Once these use cases have been categorised into different classes, it is easier to understand the key performance indicators representing the target behaviour the system must exhibit to satisfy the use case.[7]

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[3]ISO, Standards, available at http://www.iso.org/iso/home/standards.htm

[4] PetrovËiË, Uröka, Competition law and standard essential patents: A transatlantic perspective, International Competition Law Series, 42 (2014).

[5] ETSI, Why we need standards, available at http://www.etsi.org/standards/why-we-need-standards

[6] Wahlster & Winterhalter. 2020. Ten Years of Industrie 4.0. Available at https://www.mdpi.com/2413-4155/4/3/26

[7] Nidhi et al., Trends in Standardization Towards 6G, 2021: Vol 9 Iss 3, Available at https://journals.riverpublishers.com/index.php/JICTS/article/view/9677

During this phase, issues related to the spectrum and IPR are analysed. A clear IPR policy is necessary to ensure non-discrimination and attract new companies to the ecosystem. This, in turn, encourages innovation through their R&D efforts and products. Many technologies crucial for standards are protected by patents, known as SEPs. SDOs typically mandate companies involved in standardisation to widely share their SEPs under FRAND terms.

FRAND ensures that patent owners cannot block others from using the standard, but they can request royalties from those implementing the SEPs.[8] While such licensing fees can generate substantial revenues for the patent owner, this mechanism also creates dependencies that companies supplying much of the technology behind a standard could potentially exploit. If a standard is widely adopted internationally, companies whose technologies are not part of the standard might need to invest significant resources to adapt their products and remain relevant in the market (Voo and Creemers, 2021).

Further, blurred definitions of FRAND and royalty rates are subjective, leading to friction between the technology developers and its implementers, resulting in lengthy and expensive litigation. However, it is important to note that the lack of a specific definition of FRAND in the IPR policies of SDO provides them with the flexibility to balance the interests of developers and users of technology and keep them invested in the process of standards development. Along similar lines, the European Commission also acknowledges that there is no one-size-fits-all solution to what FRAND is: what can be considered fair and reasonable can differ from sector to sector and over time.[9]

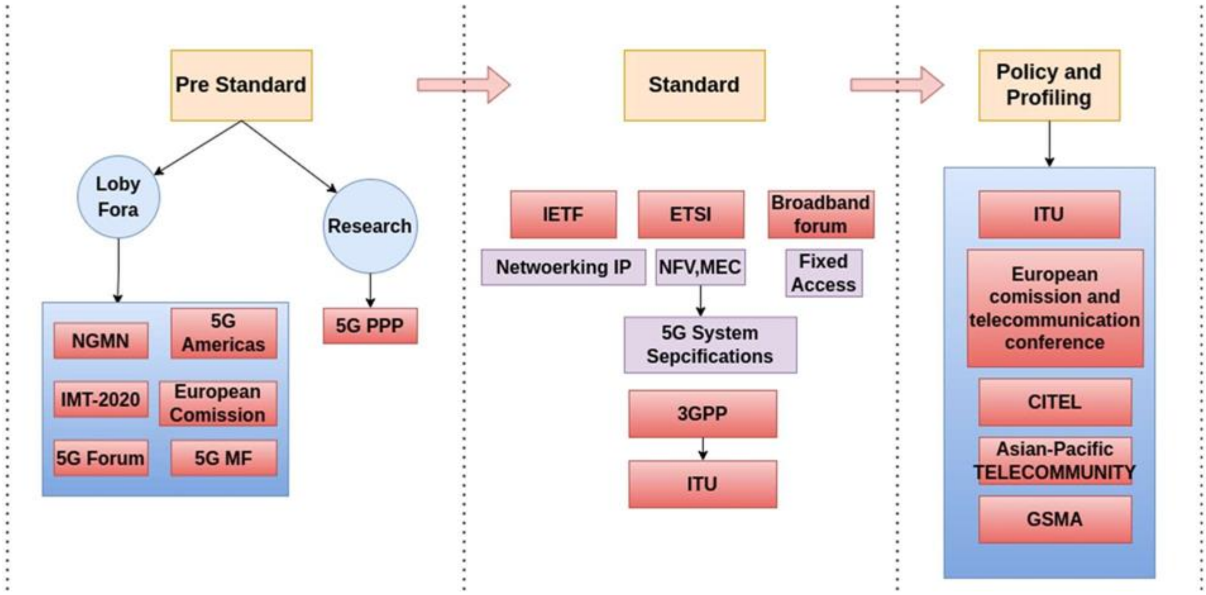
- **Standardisation of Technical Specifications**
  The next phase involves defining technical standards, requiring collaboration among various SDOs. The expectation is that ITU-R will specify the requirements for the new IMT-2030 radio family. Concurrently, 3GPP will serve as the primary SDO responsible for defining the entire 6G system and its radio aspects, ensuring alignment with ITU-R requirements.[10]

- **Policy and Profiling**
  The final phase of the standardisation process encompasses policy and profiling activities. Examples of such activities include identifying the spectrum for 6G applications and defining rules for its utilisation.[11] The figure below outlines the

8 Pohlmann and Blind, 2020. Available at https://www.sciencedirect.com/science/article/pii/S030859612100015X
9 Standard Essential Patents and the Internet of Things. 2019. Available at https://www.europarl.europa.eu/RegData/etudes/IDAN/2019/608854/IPOL_IDA(2019)608854_EN.pdf
10 Supra Note 7
11 *Ibid*

stakeholders involved in each step of the standardisation process. In the pre-standard phase, forums related to 5G are engaged. The standard-setting process includes involvement from Standard Development Organisations (SDOs), such as IETF and 3GPP, in addition to fixed access forums and ETSI. The policy and profiling stage is primarily divided between ITU and GSMA.

Figure 1: The Telecommunications and Internet Standardisation Process[12]



2.3 Standard Setting Bodies

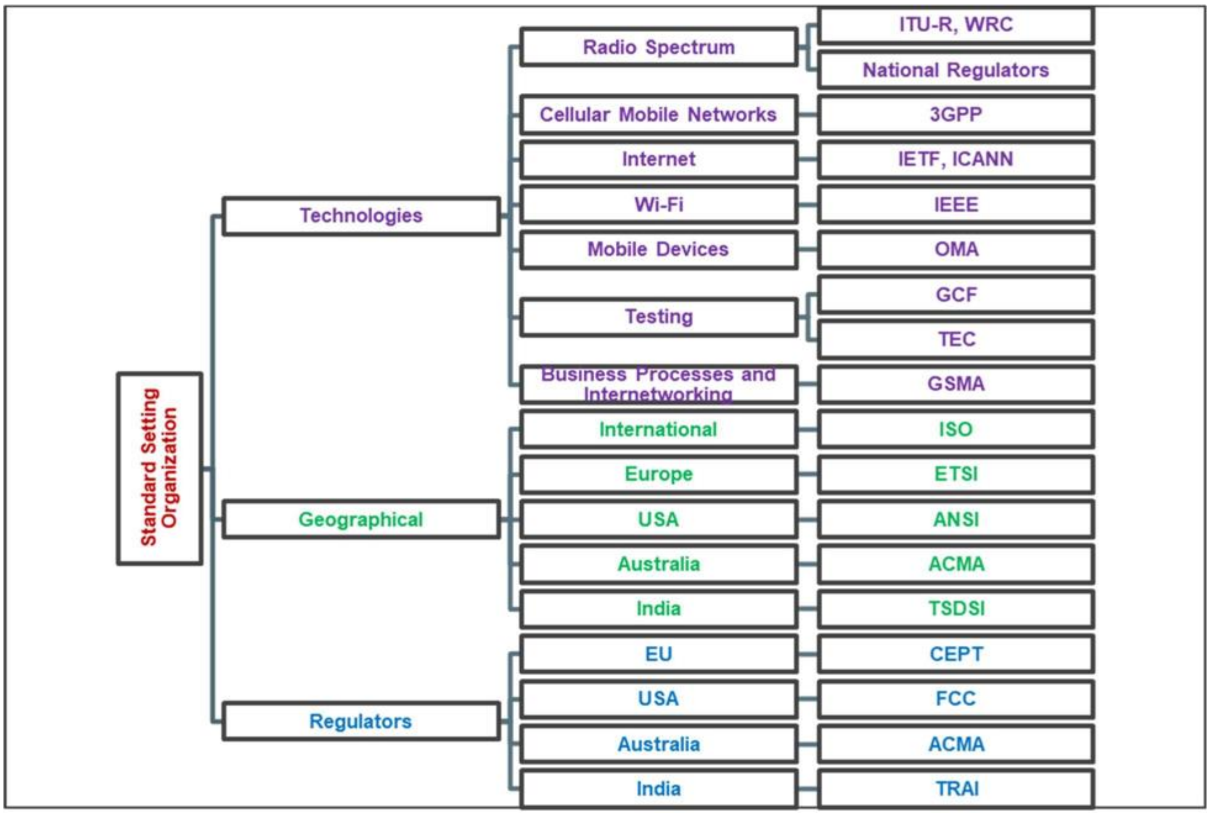
The success of a technology is not solely attributed to a single standardisation body but involves multiple entities collaborating closely, as illustrated in the figure below. A crucial aspect for ensuring the success of a technology is the availability of radio spectrum and the coordination of spectrum bands across countries. Radio spectrum, being a scarce resource, is essential for providing wireless communications and requires coordination for efficient use across all communication needs. The primary entities responsible for identifying spectrum needs for mobile communications and establishing rules for its use are ITU-R.

Decisions concerning global coordination of the radio spectrum are predominantly made at the World Radiocommunication Conference (WRC). It is important to note that while national regulators oversee the spectrum, the ultimate ownership rests with them. Following the spectrum allocation, common requirements and system goals need to be defined, and subsequently, technology components must be developed.

[12] 6G Symposium Europe: Shaping Industry and Society Beyond 5G. Available at: https://www.6gworld.com/spring-2021-6gsymposium-thank-you/?submissionGuid=68f73683-60cb-4ec8-bbe7-f185be9759ae

- 3GPP: The main standardisation body delivering technical specifications for cellular mobile networks including 6G and beyond
- IETF: For the IP protocol suite developed for the Internet, including standards for IP version 6
- IEEE: For the interworking of unlicensed Wi-Fi networks with licensed cellular mobile networks
- OMA: For communication device management including IoT and mobile devices
- GCF: For testing procedures for devices
- GSMA: For business rules and internetworking

Figure 2: Taxonomy of Standards and Standard Setting Organisations (Authors' own)



Apart from the above broad areas of standardisation, there are many application-specific standards and SSO, including cyber security, digital payments, and digital identity to name a few.

Each organisation possesses its unique membership structure, comprising a blend of public and private sector members. These entities also establish their distinct standards, determination processes and operational rules. For instance, 3GPP mandates that members attend meetings regularly to maintain voting privileges, with a limit of two consecutive missed meetings. To join 3GPP, individual members must be affiliated with one of the organisational partners (ETSI, ATIS, CCSA, ARIB, TSDSI, TTA, or TTC).

If a member misses three consecutive meetings, voting rights are reinstated only after attending two subsequent meetings following the initial three-meeting absence period. In 3GPP, voting rights for individual members hinge on meeting attendance requirements, with contributions developed and refined through a consensus-based approach within the respective working groups, minimising the occurrence of formal technical votes.

Participating in each standards-setting engagement incurs considerable expenses. For instance, in 3GPP technical votes, only members meeting attendance requirements can vote, placing those with the means to dedicate company representatives and cover their travel costs at an advantage. Involvement in international discussions on standards setting ensures companies stay informed about overall market innovation, guiding the direction of future research and development (R&D). The rationale behind government support for private sector standards engagement, whether through grants or tax incentives, is evident. Positive externalities from participation in standards-setting organisations are not immediately recoverable, justifying government support to boost participation rates and counteract incentives offered by other governments, particularly China.

The 3GPP, the primary catalyst behind 5G specifications' development, was conceived with transparency, consensus, and fairness as its fundamental principles. Today's cellular standards heavily rely on the 3GPP, whose specifications are not only relevant in the present but also crucial for the complex 6G future. However, this does not guarantee consistency, nor does it imply that smaller standards-setting bodies or those with weaker frameworks could not be undermined. If a country can orchestrate votes to align with the government's desired outcome at standard-setting organisations, regardless of the best technology, specific companies will gain accumulating advantages, likely reinforcing the consolidation of the equipment supply chain.

Governments worldwide must take this concern seriously, actively monitor for potential abuses in the process, and underscore them when identified. However, governments should refrain from adopting similar tactics, as it may lead to further withdrawal or fragmentation of the standards process. Instead of deploying additional government representatives or intricately coordinating specific priorities, policymakers should concentrate on promoting robust governance structures to ensure a fair process across standards bodies.[13]

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[13] Mapping the International 5G Standards Landscape and How It Impacts U.S. Strategy and Policy. 2021. Available at https://itif.org/publications/2021/11/08/mapping-international-5g-standards-landscape-and-how-it-impacts-us-strategy/

Standards organisations operate under the shared commitment that standards developed through industry-led processes yield superior outcomes compared to those directed by governments. Governments leverage competition among telecommunication firms and supply chain participants to identify the most efficient and effective standards for deploying and utilising 5G and its applications. These standards are established at the international, regional, and local levels.

However, there is a growing concern that China intends to replace outcomes determined by private industry members, operating independently within standards-setting bodies, with government-selected alternatives. This raises apprehensions about the fairness of the process and the ability to achieve the best standards when there is coordination to bypass established procedures.

2.4 Comparison of Different Types of Standard Setting Processes

Companies can choose to implement or not any standard, depending on their goals and economic interests. Sometimes, these standards are connected to rules set by the government. In the USA, for example, standards might be used as a basis for regulations. In China, some standards are mandatory, which means companies must follow them. In the European Union, standards are sometimes built into regulations. These regulations might refer to existing standards to show that they are being followed, or they might instruct European groups to create specific standards. The reason behind this decision is more about securing short-term benefits through trade protectionism rather than being driven by the economic principles of standardisation.

On the contrary, industry standards are created by industry consortia and can either be *de facto* or *de jure* standards. They are typically driven by industry groups and are designed to meet specific needs that may not be addressed by formal SDOs. De facto standards emerge naturally through market use. Even without being officially adopted by Standard SDOs, they become widely accepted and used because they are often seen as the most efficient or reliable option in their field. Examples include the QWERTY keyboard and the MP3 audio format.

De jure standards, on the other hand, are created and approved through formal processes within SDOs like IEEE, ISO and 3GPP. Over time, some de facto standards can transition into de jure standards. For instance, HyperText Markup Language (HTML) and Adobe's Portable Document Format (PDF) were initially accepted as de facto standards and were later officially adopted as de jure standards by ISO.

The industry-led collaborative standards generally yield better results compared to those derived from a government-directed process. This approach leverages competition among telecommunication firms and supply chain members to delineate the most effective standards, those that ensure efficient deployment and utilisation of telecommunication networks and associated applications. These standards are established at various levels: international, regional, and local. Unfortunately, concerns arise over undemocratic intentions to supplant these industry-driven outcomes with government-selected alternatives, a process potentially concealed within the decision-making structure of standard-setting organisations.[14]

This approach could potentially compromise the ability of private industry members to maintain their independence within these organisations, thereby inhibiting the emergence of 'optimal' standards through a fair and unbiased process.

De Facto Standards	De Jure Standards
De facto standards emerge when a practice, behaviour, or configuration gains acceptance through repeated use, driven by market dynamics and dominant enterprises. These standards evolve within communities, industry alliances, associations, and consortia. The standardisation process relies on active and sustained participation from market actors within a culture that supports such engagement. Compliance with de facto standards is voluntary, reflecting their organic development based on market trends.	De jure standards are developed through a formal process under a formal SDO. While compliance with de jure standards is generally voluntary, legal codes or regulations in certain jurisdictions may enforce them, making adherence mandatory. Examples of SDOs overseeing voluntary de jure standards development include the 3GPP, ISO, ITU-T, and Organisation for the Advancement of Structured Information Standards (OASIS). Over time, *de facto* standards can become *de jure* standards

Development of standards should be open and collaborative which has rightly gained significant traction in recent times due to its holistic approach under the guidance of SDOs.[15] Despite some drawbacks such as not being conducive to innovations, the process has achieved noteworthy technological advancements in telecommunications. At the heart of collaborative standardisation lies a harmonious equilibrium of interests and motivations of all stakeholders involved, such as technology contributors, policymakers, and standard users, which is exemplified by licensing on FRAND terms. Open and collaborative standards are developed or ratified through a consensus-driven process which follows an open and transparent IPR policy.[16]

14 "The US. Needs to Get in the Standards Game-With Like-Minded Democracies," Lawfare, April 2, 2020, https://www.lawfareblog.com/us-needs-get-standards-gamepercentE2percent80 percent94-minded-democracies.

15 https://www.itu.int/hub/2021/03/technical-standards-call-for-collaboration/

16 ETSI, Guide on intellectual property rights, available at http://www.etsi.org/images/files/IPR/etsiguide-on-ipr.pdf

Most SDOs are open to all, and they usually ask contributors to licence SEPs[17] to implementers on FRAND terms, with or without royalties.[18] However, the unclear definition of FRAND has been causing conflicts between technology developers and implementers. Such challenges could cause an imbalance between the interests of technology developers and technology implementers and obscure the bright prospects of 6G technology.[19]

2.5 Global Standard For 6G

The global standard requires the open and collaborative participation of a wide range of stakeholders, including technology vendors, service providers, standard-setting organisations, and government regulators.[20] This ensures that all stakeholders have a say in the development process, which leads to more inclusive and transparent standards.[21] This promotes interoperability between different devices and networks, ensures that the technology works together seamlessly, and enables competition and innovation in the market.[22]

IPRs necessary for implementing the standard must be licensed to all applicants worldwide on a non-discriminatory basis. This can be done either: for free and under reasonable terms and conditions; or on reasonable terms and conditions, which may involve monetary compensation. The negotiations are handled by the involved parties and occur outside the SDO. According to ITU:

> "Open Standards" are standards made available to the general public and are developed (or approved) and maintained via a collaborative and consensus-driven process. "Open Standards" facilitate interoperability and data exchange among different products or services and are intended for widespread adoption.

Global interoperability, facilitated by universally adopted standards, presents an opportunity for companies to market their products on an international scale. This global approach underpins economies of scale and reduces the costs associated with technology development and production. Subsequently, pricing for consumers and

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17 SEPs are patents essential to implementing a specific industry standard. This means that to manufacture standard-compliant electronic devices such as mobile phones and tablets, manufacturers must use technologies covered by one or more SEPs.

18 Rao, D and Shabana N, Standard essential patents, Singhania & Partners, available at http:// Www.Singhania.In/Wp-Content/Uploads/2016/04/Standard-Essential-Patents.Pdf

19 Best, Jo, The race to 5G: Inside the fight for the future of mobile as we know it, available at http:// www.techrepublic.com/article/does-the-world-really-need-5g/

20 https://arxiv.org/pdf/1904.03413

21 "The Middle Kingdom Galapagos Island Syndrome: The Cul-De-Sac of Chinese Technology Standards", https://itif.org/publications/2014/12/15/middle-kingdom-galapagos-island-syndrome-cul-de-sac-chinese-technology/

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promoting the pace of innovation. In the absence of these universal standards, these positive externalities diminish, thereby slowing innovation and escalating costs.

The wireless communications industry distinguishes itself through its inherent necessity for interoperability, where a successful system necessitates a cohesive interplay between network components, particularly given the increasing specialisation of different firms. The requirement for consensus among competitors, each with its proprietary technology, reduces the likelihood of undue market power exertion by any single entity. This fosters competitive markets both upstream and downstream.[23]

An example of effective global open and collaborative standardisation in mobile communications is the 3GPP partner project. Over the past two decades, it has played a pivotal role in creating and standardising technologies for 3G, 4G, and 5G. This facilitates the harmonisation of technological goals across America, European, and Asian technology zones. As each technology undergoes standardisation, 3GPP can incorporate national options within the global standards, considering national radio frequency band allocation and network requirements.

To ensure that technologies can be used worldwide and potentially beyond, it is crucial to have globally developed, adopted, and deployed standards. As we progress into 6G, delivering connectivity and services to various industries and users globally, having a unified set of global standards for 6G becomes increasingly crucial. This requires global collaborations between governments, research institutions, telecom giants, semiconductor makers, and hardware and software developers.

Historically, wireless technology encountered simultaneous yet competing standards. For instance, the progression of 2G and 3G was characterised by a technological divide between the United States and Europe.[24] The US saw the deployment of Code-Division Multiple Access (CDMA) networks, a development by Qualcomm, while Europe mandated the use of Global System for Mobile Communications (GSM) networks, a creation by Ericsson, to favour its production industries.[25] This period also witnessed China advocating for its 3G standard, Time Division Synchronous Code Division Multiple Access (TD-SCDMA), which added a further layer of complexity to the globalisation of the wireless market.[26]

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23 Tsilikas, Haris, Collaborative standardisation and disruptive innovation: The case of wireless telecom standards, Max Planck Institute for Innovation & Competition Research Paper No. 16-06 (2016), available at https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2783372

24 https://www.politico.eu/article/6g-race-eu-united-states-china/

25 Richard Bennett, "Sharing the Risk of Wireless Innovation" (ITIF, October 2009), https://itif.org/files/Wireless_Innovation.pdf.

26 "Testimony for: A 'China Model?' Beijing's Promotion of Alternative Global Norms and Standards," US.-China Economic and Security Review Commission,

Already now, when building 6G networks, many countries are abandoning vendors from individual governments. The fear is again rising that the West may lose in the global race for mobile standards in 6G which can lead to fragmentation in 6G ecosystems between China and the West, negatively affecting users.[27] We must avoid adopting incompatible standards in 6G, as we have done in the past as it leads to a restricted availability of devices and network equipment.

Organisations such as the Next G Alliance in North America, FutureForum in China, 6G-IA in Europe, 6G Forum in Korea, and the Beyond 5G Promotion Consortium in Japan are at the forefront of the research phase for future 6G systems. As 6G is expected to enable new use cases and support emerging technologies such as augmented and virtual reality, autonomous vehicles, and the internet of things, collaboratively developed standards will enable the sharing of knowledge, expertise, and resources, which leads to the development of new and innovative technologies.[28] By developing standards collaboratively, stakeholders can identify and address potential issues early in the process, leading to enhanced safety.[29]

6G networks will digitise more legacy, industrial, and critical real-world functions; there is an increased vulnerability to disruptions caused by 6G-enabled attacks. The hardware supply chains essential for 6G adoption and operations will not only be crucial for advancement but also potential targets for attacks, becoming a competitive battleground.

The ITU aims to finalise the standardisation of IMT-2030 6G by the end of 2030, concurrent with 3GPP completing their R23 6G standardisation.[30] The ITU established a workgroup in July 2018 to research B5G/6G systems.[31]

While there is currently limited information available about 6G standards, it is anticipated that international standardisation bodies will define them by 2030.[32] Recognising the growing demand for IoT-related products in the future, both industry players and policymakers acknowledge the necessity of developing the next

https://www.uscc.gov/sites/default/files/testimonies/March percent2013 percent20Hearing_Panel percent203_Naomi percent20Wilson percent20ITI.pdf.

27 https://www.lightreading.com/5g/ericsson-ceo-warns-china-will-be-formidable-if-5g-or-6g-splits/d/d-id/771650

28 Supra Note 23

29 *Ibid*

30 Viswanathan H, Mogensen PE (2020), Communications in the 6G era, IEEE, available at https://ieeexplore.ieee.org/document/9040431/

31 International telecommunications union focus group on technologies for the network, available at https://www.itu.int/en/IUT-T/focusgroups/net2030/

32 Mourad A, Yang R, Lehne PH, De La Oliva A. (2020). A baseline roadmap for advanced wireless research beyond 5G. Electronics 9(2):351, available at https://www.mdpi.com/2079-9292/9/2/351

generation of wireless networks. Research and development for 6G are underway, with network availability expected by 2030. Experts stress the importance of a unified global standard for 6G, considering it a cornerstone of industry digitalisation. Achieving a global consensus on the technical specifications for 6G technology is, therefore, deemed crucial.

The policy engagement with 6G standards has been largely driven by national security concerns, which have limited their focus to specific areas. Increasing tensions in the US-China are standing to bleed into telecommunication advancements–right from the point of standard. However, this narrow approach makes it difficult to address economic issues through international rule-setting. Moreover, the standards ecosystem is complex and requires attention to ground-level challenges, such as managing consensus across different bodies, engaging industry stakeholders in a lengthy process, and ensuring the overall quality of standards outcomes.

Quality research and development are also essential for producing robust standards proposals, which require funding and resources. With growing geopolitical tension, these challenges stand to be exacerbated. While increased attention to standards is a good sign, it should lead to a deeper understanding of their importance and value in emerging technology rule-setting, as well as their role in facilitating digital trade.

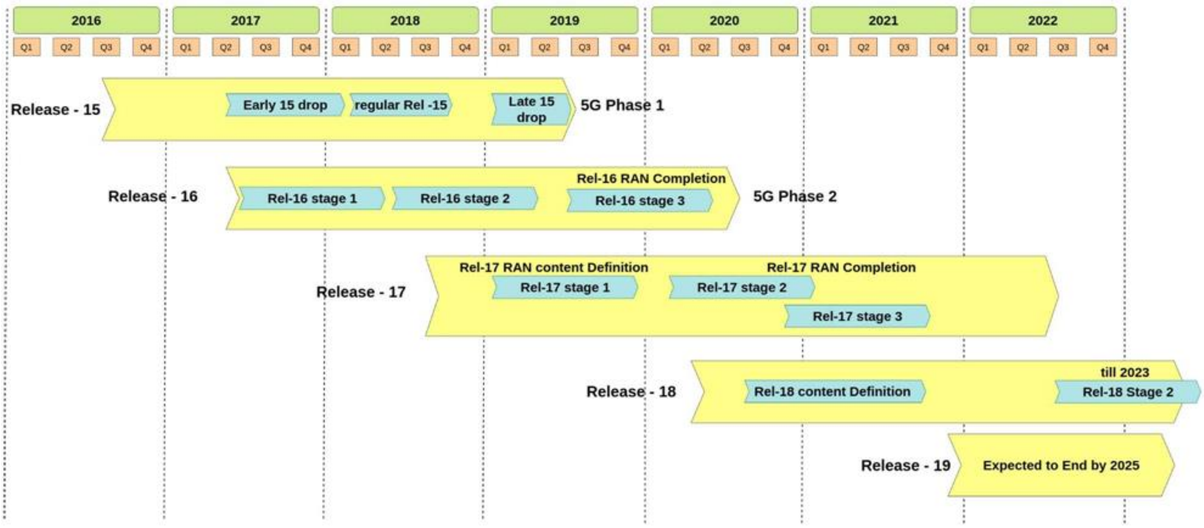
Chapter 3

Standards for 5G, Learnings for 6G: A Technical Analysis

The 3GPP uses a parallel "Releases" system that provides developers with a stable platform for implementing features at a given point and then allows for adding new functionality in subsequent Releases. Standardisation activity for 5G began in 2015 with the SMARTER (New Services and Markets Technology Enablers) study (Anwer et al, 2018), which addressed four different topics: massive Internet of Things, Critical Communications, enhanced Mobile Broadband, and Network Operations, covering more than 70 different use cases. This formed the foundation for the development of 5G standards.

Figure 3 provides a roadmap of the 5G standardisation activities. From the initial Release 15 to the final Release 20 in 2026, the elapsed time for the standard-setting process is about 10 years. It is expected that 6G will also roughly follow a similar timeline, starting with 6G Basic Release 21 in 2027 (Light reading, 2022).

Figure 3: The Telecommunications Standardisation Roadmap[33]



3.1 Release 15

This is also called 5G phase 1 with a primary focus on enhanced mobile broadband. This initial specification enabled non-standalone 5G radio systems to be integrated into previous-generation LTE networks. Release 15 was further expanded to cover

33 About 3GPP: Available at: https://www.3gpp.org/about-3gpp

"standalone" 5G, with a new radio system complemented by a next-generation core network as well as additional architecture options. The 5G New Radio (NR) specified in Release 15 supports low-latency, beam-based channels, new high-frequency spectrum bands, massive Multiple Input Multiple Output (MIMO) with large numbers of controllable antenna elements, scalable-width sub-channels, carrier aggregation, cloud Radio-Access Network (RAN) capability, and coexistence with LTE. (official 3GPP documentation, release 15).

The implementation of the 5G protocol in Rel-15 underwent a transition through stages, which were split into three stages, as outlined below:

1. Early Rel-15 drop: This stage focused on the third architecture option, also known as non-standalone NR (NSA NR). It employed the use of an LTE-A system of LTE base stations (called eNB) added to NR base stations (called gNB) and an Evolved Packet Core network (EPC) without any involvement of the 5G core network (NGC). This phase of the Rel-15 standard was frozen in Dec 2017.
2. Regular Rel-15 freeze: This stage focused on the standalone NR architecture option 2, a connection of NR base stations (called gNB) to the 5G core network (called NGC) without involving any LTE. Apart from option 2 architecture, option 5 architecture was also completed in this phase; this phase of the Rel-15 standard was frozen in June 2018.
3. Late Rel-15 drop: This stage focused on architecture option 4, which employs the deployment of an LTE base station to a Standalone NR network such that the control plane is managed via the NR base station. Also, architecture option 7, employs the deployment of an LTE base station to a Standalone NR network such that the control plane is managed via the LTE base station together with NR-NR dual connectivity. This phase of the Rel-15 standard was frozen in Dec 2018.

3.2 Release 16

This release is called 5G phase 2. Release 16 delivers system solutions for new use cases beyond mobile broadband with a focus on enterprise applications with enhanced ultra-reliable, low-latency communication (eURLLC). Specifically, Rel-16 is the first release to standardise the 5G positioning framework using NR for V2X support. Some of the key areas where release 16 was focused on:

- Advanced positioning framework for Vehicle-to-everything (V2X) support using Global Navigation Satellite System (GNSS)
- User Identities, Authentication, multi-device (Network) Slicing
- UE radio capability signalling optimisation
- Cellular IoT support and evolution
- Enablers for Network Convergence Enhancement

From a business angel, Release 16 enables applications for new vertical industries and deployment scenarios:

- Integrated access and backhaul (IAB)
- NR in unlicensed spectrum
- Features for Industrial Internet of Things (IIoT) and ultra-reliable low latency communication (URLLC)
- Intelligent transportation systems (ITS) and V2X communications
- Positioning

The freeze of Rel-16 stage 3 took place in June 2020. (Official 3GPP documentation, release 16)

3.3 Release 17

Release 17 is dedicated to consolidating and enhancing the concepts and functionalities introduced in the previous Releases while introducing a small number of brand-new Features.

The improvements relate to all the key areas of the previous Releases: services to the industry (the "verticals"), including positioning, private network, etc.; improvements for several aspects of 5G supporting the Internet of Things (IoT) including NR positioning, both in the Core Network and in the Access Network; of proximity (direct) communications between mobiles, in particular in the context of autonomous driving V2X; in several media aspects of the user plane related to the entertainment industry (codec, streaming, broadcasting) and also of the support of Mission Critical communications. Furthermore, several network functionalities have been improved, e.g., for slicing, traffic steering, and Edge-computing. Standards for AI/ML using NG NR were also started in this release.

The Radio interface and the Access Network have been significantly improved too (MIMO, Repeaters, 1024 Quadrature Amplitude Modulation (QAM) for downlink, etc.). While most of the improvements target 5G/NR radio access (or are access-agnostic), some improvements are dedicated to 4G/LTE access. The network data analytics function (NWDAF) was introduced to analyse the Big Data generated in network data for Quality of Service (QoS), dynamic traffic steering, and resource management (Zhang and Zhu, 2020).

As for the new features, the main feature of this Release is the support of satellite access. It is expected that the 6G standardisation process will begin in Release 21 by 2026. (Official 3GPP documentation, Release 17).

3GPP adopts a set of key principles for AI-enabled RAN to focus on AI applications with potential standardisation impact for RAN intelligence. 5G brings more stringent requirements for Key Performance Indicators (KPIs) such as latency, reliability, user experience, and others. Jointly optimising those KPIs is becoming more challenging due to the increased complexity of foreseen deployments. For this reason, following RAN plenary approval, 3GPP RAN3 has recently started a new Release-17 study on the applications of AI/ML to RAN. This is expected to continue with 6G releases as well.

3.4 Release 18

Release 18 will deliver 5G-Advanced, as the mid-point of 5G standardisation. Key fields where 5G-Advanced will focus on are:

- Self-driving cars
- Smart cities
- Smart Homes
- Industry Automation
- Augmented Reality

There is also more emphasis on reliable accurate positioning system standards, especially for IIoT and V2X connectivity enabled by Road Side Units (RSU). This 5G-Advanced feature will help to grow mobile subscribers from 5.1 Billion to 5.8 Billion and 10 Billion IoT connections to 25 Billion IoT Connections by 2025 (Source: GSMA).

3.5 Release 19

In the released poster 18, 3GPP partners have discussed the early release 19 studies which are:

- Network of Service Robots with Ambient Intelligence
- Energy Efficiency as service criteria
- Upper layer traffic steering, switching and split over dual 3GPP access
- Uncrewed Aerial Vehicles (Phase 3)
- Satellite Access (Phase 3)
- AI/ML Model Transfer (Phase 2)
- Integrated Sensing and Communication
- Ambient power-enabled Internet of Things
- Localised Mobile Metaverse Services
- Joint Communication and Systems including extending positioning systems for drone locations, emergency response and public safety

3.6 Spectrum Requirements for 6G

6G has the potential to create a widespread networking infrastructure where users would not need to select the best communication network. In this infrastructure, each node would possess the intelligence to detect the channel's conditions and the quality of service specifications at any other node. This would allow the network to determine the appropriate network, such as cellular, wireless LAN, Bluetooth, or ultra-wideband (UWB), based on the use case and network availability. For 6G communication standards to achieve this, they need to be designed in a way that integrates all wireless technologies. Wi-Fi, Bluetooth, UWB, VLC, UAVs, biosensors, and satellite communications should all come together under one standard, enabling them to connect seamlessly with each other.[34]

In 5G, the spectrum is allocated based on the applications. Since spectrum is a scarce resource, its availability is a challenge. Therefore, reusing the existing spectrum bands is essential in 6G to meet high bandwidth demands. The standardisation initiatives to exploit the licensed and unlicensed spectrum will certainly be of fundamental importance in the coming years. In 2019, the Federal Communications Commission (FCC) opened a new spectrum range to boost 6G research activities.[35]

It has allowed frequencies between 95 GHz and 3 THz for research purposes and labelled it "the far frontier of spectrum policy." As 6G is going towards such high bands spectrum while operating in the ultra-high radio frequencies, enormous challenges arise in terms of propagation. Somehow, coexistence is of crucial importance for access to the frequency spectrum.

The utilisation of the terahertz spectrum, ranging from 0.3 THz to 3 THz, distinguishes the sixth generation of communication (6G). Expected characteristics include a remarkably high data transfer rate (up to 1 Tbit/s, compared to 1 Gbit/s in 5G), extremely low latency (as low as 0.1 ms, versus 1 ms in 5G), versatile coverage extending to space and water, connectivity for an extensive number of devices (up to 10 million per sq. km), a decentralised network architecture, and the incorporation of artificial intelligence for self-sustaining networks, among other advancements. The millimetre waves and Terahertz spectrum bands that will be used in 6G networks have several differences from conventional radio communication bands:

1. The mmWave/ THz signals have a much higher susceptibility to blockages compared to the signals at the lower frequencies. The mmWave/THz communication relies heavily on the availability of line-of-sight (LOS) links due to the very poor propagation characteristics of the non-line-of-sight (NLOS) links.[36]
2. The second important feature of mmWave/THz communication is its high directivity. To overcome the severe path loss at these high frequencies, it is necessary to use a large number of antennas at the transmitter and/or receiver side.[37]
3. Electromagnetic (EM) waves suffer from transmission losses when they travel through the atmosphere due to their absorption by molecules of gaseous

34 https://hcis-journal.springeropen.com/articles/10.1186/s13673-020-00258-2
35 Kinney et al., 2019,
36 F. Boccardi, R. W. Heath, A. Lozano, T. L. Marzetta, and P. Popovski, "Five disruptive technology directions for 5G," IEEE Communications Magazine, vol. 52, no. 2, pp. 74–80, 2014.
37 *Ibid*

atmospheric constituents including oxygen and water. These losses are greater at certain frequencies, coinciding with the mechanical resonant frequencies of the gas molecules.[38]

The above characteristics require standards to be developed both for licensed bands by 3GPP and for unlicensed bands by IEEE. Given that THz communications are still in its nascent phase, its standardisation efforts are just beginning. The IEEE 802.15.3d-2017 was proposed in 2017, which is the first standard for THz fixed point-to-point links operating at carrier frequencies between 252 and 321 GHz. For the development of nano-network standards at THz frequencies, IEEE P1906.1/Draft 1.0 discusses recommended practices for nano-scale and molecular communication frameworks.[39] Further standardisation activities are expected from 3GPP as well soon.

One of the important areas of the application of molecular communication is in the Internet of Wearable Things (IoWT) that are used in wearables and implants in human beings. Deeply into the body, molecular communications construct the inner tier of IoWT systems, where IoWT devices (e.g. biological and artificial micro/nanochips and sensors) are injected into the vein to travel throughout the entire body.[40]

Prime examples of IoWT services and applications exploiting molecular communications are early detection and mitigation of infectious diseases,[41] precision medicine, and complex medical treatments.[42] To form an IoWT system, standard sensing interfaces and efficient recognition algorithms play important roles in connecting and collaborating with IoWT devices.[43] Similarly, communication standards and interfaces need to be developed for molecular communication as part of the 6G standardisation process.

3.7 Spectrum Harmonisation in WRC 23

In the recently concluded World Radio Telecommunications Conference (WRC 23), several decisions have been taken to harmonise the radio spectrum for "5G and beyond" networks. The critical ones are listed below:

1. Harmonisation of the spectrum band in 3.3-3.4 and 3.6-3.8 GHz will allow about 500 MHz of spectrum in this mid-band to be released for IMT services.

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38 M. Marcus and B. Pattan, 2005, https://www.semanticscholar.org/paper/Millimeter-wave-propagation%3A-spectrum-management-Marcus-Pattan/6408245df6125ff7429990ece379613bfc0aa48f

39 IEEE, 2014; Elayan, et al., 2020, https://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=8901159

40 T. Islam, et al., 2020

41 I.F. Akyildiz, et al., 2020, https://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=9145564

42 T. Nakano, 2020, https://www.mdpi.com/2072-6694/12/1/221

43 Dao, 2022

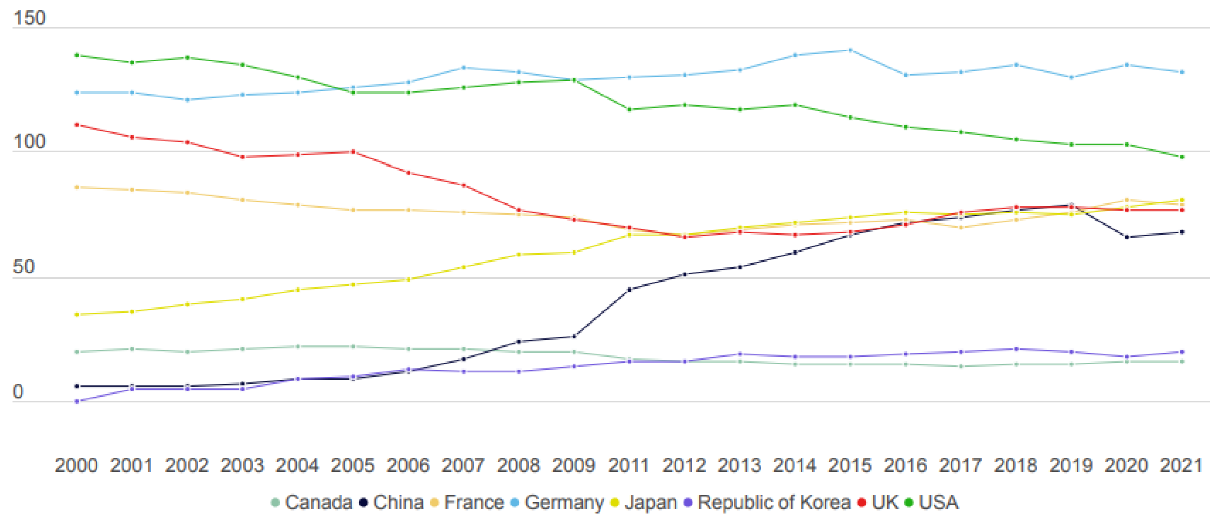
2. The 2 and 2.6 GHz bands emerged as a spectrum for support of high-altitude platform stations as IMT base stations (HIBS), which will enable better rural and remote area connectivity for 5G and beyond networks.
3. The upper 6 GHz spectrum (6.425-7.125 GHz) has been identified by IMT services in Europe, Africa and a few other countries. The conference also adopted an international treaty provision to explicitly recognise that this spectrum is used by wireless access systems such as Wi-Fi. This provides country regulators flexibility in allowing 6 GHz to be allocated as licensed or unlicensed. WRC 23 has made it clear that IMT services can exist only in the upper 700 MHz of this spectrum band, thereby opening up the lower band (5.925-6.425 GHz) as an unlicensed spectrum.
4. The regulators also agreed to study the 7-8.5GHz band for 6G in time for the next ITU conference in 202.

Chapter 4

Role of India and Australia in the Indo-Pacific Context

Despite the economic and political significance of standards, there is an uneven participation of states in their development, leading to what is commonly known as the standardisation gap, especially between developed and developing countries. Various initiatives aim to address this gap, such as the ITU's programme dedicated to rectifying disparities in the ability of developing countries to access, implement, and influence ITU's international standards. For several decades, Western actors, particularly the USA and some European countries, were at the forefront of international standards development.

However, the landscape began to shift in the 1990s and 2000s with the increasing prominence of Asian actors, including Japan, the Republic of Korea, and China, in both economic and technological spheres. The below figure shows the evolution of ISO TCs and SCs secretariat positions held by selected countries between 2000 and 2021[44]:



Chinese policies, particularly outlined in the China Standards 2035 initiative, seek to dominate future industries which have raised the geopolitical tension around 6G and its standard-setting process. This raises concerns that the upcoming standard for the next generation of mobile internet, 6G, may not achieve global consensus. To avoid a repetition of the situation observed with the 5G standard, where Chinese companies

44 https://www.diplomacy.edu/wp-content/uploads/2021/12/Geopolitics-of-digital-standards-Dec-2021.pdf

like Huawei and ZTE gained a substantial global market share before significant cybersecurity concerns emerged, the US and an increasing number of governments are advocating for a more cautious approach. Many countries have already restricted their high-tech firms from exporting 5G technology to Huawei, and this restriction has been expanded to cover most other technologies.

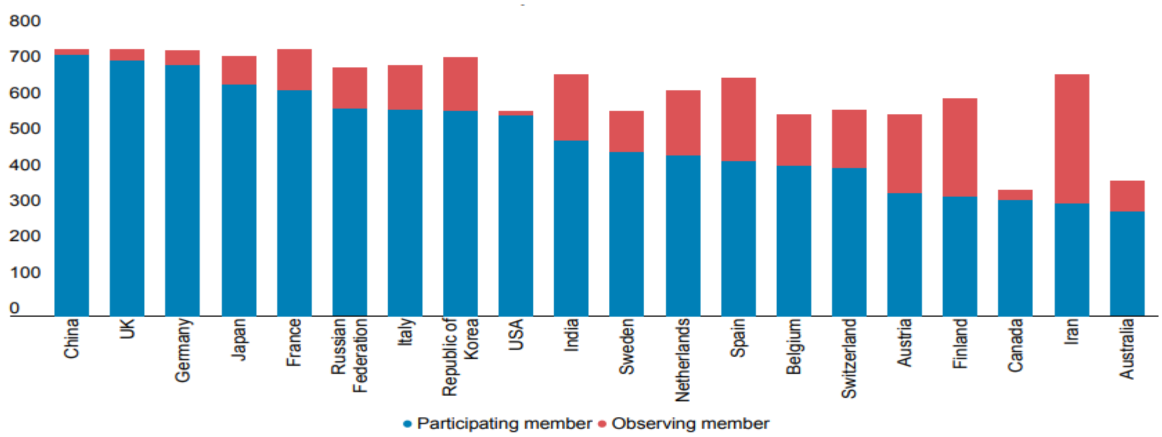
4.1 Fragmenting Technology

The world is changing, and geopolitical tensions are making countries rethink their security, especially with communication networks becoming crucial in the digital age. Many nations are working on securing the supply chain and improving telecommunication infrastructure. Countries like the US, China, India, and Europe are investing heavily to lead in future communication networks.

At present, standards serve as a significant focal point in the larger geopolitical competition between the US and China. While China has strategically employed hierarchical industrial strategies to bolster its global standing, the US maintains a prominent role in the international standards community by leveraging its industrial supremacy to establish de facto standards and capitalise on market size.

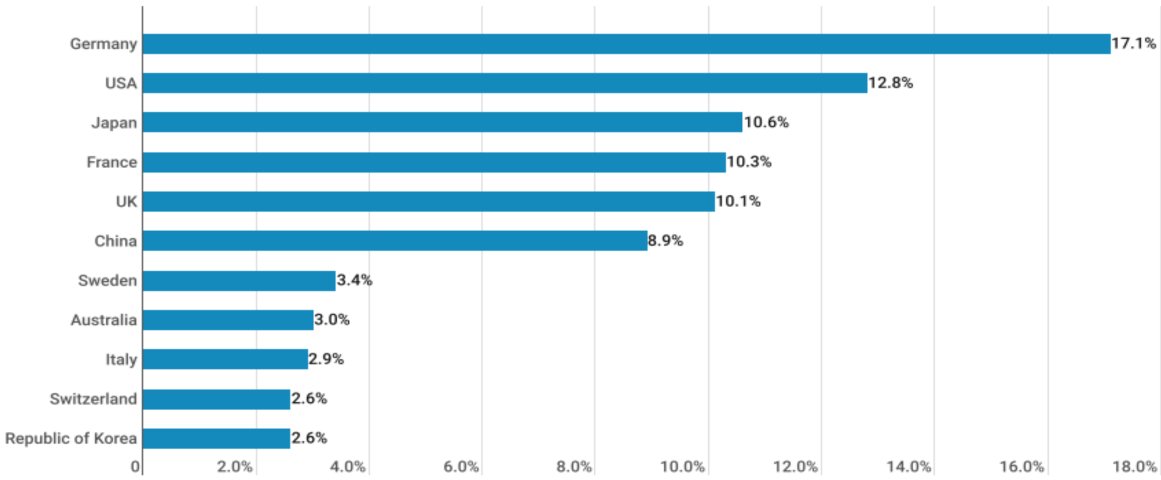
As of November 01, 2021, China actively participates in 732 Technical Committees (TCs) and Subcommittees (SCs), with an additional 13 committees where it holds observer status (refer to Figure 1). This positions China as the leading country with the highest level of active engagement in TCs and SCs. Following China, other countries with significant involvement include the UK (714), Germany (703), Japan (646), and France (633).[45]

Based on ISO membership data, the figure below illustrates participation in ISO Technical Committees (TCs) and Subcommittees (SCs): Top 20 most active countries by the number of TCs and SCs they are actively engaged in as participating members.



45 https://www.diplomacy.edu/wp-content/uploads/2021/12/Geopolitics-of-digital-standards-Dec-2021.pdf

Merely participating in committees does not automatically equate to influence. Countries often assess and compare their influence within ISO by examining the number of Secretariat positions they hold in Technical Committees (TCs) and Subcommittees (SCs). As of November 2021, China occupies 6th place (with 68 secretariat positions,38 around nine percent of all positions), after Germany (132), the US (98), Japan (81), France (79), and the UK (77):



Countries with a larger quantity of patent claims exert a more significant influence on the establishment of industry standards.[46] Research conducted by the Tokyo-based Cyber Creative Institute indicates that, globally, the largest proportion of 6G patent applications originate from Chinese companies and universities. There is limited information regarding patents granted. The institute scrutinised approximately 20,000 patent applications about nine core 6G technologies— encompassing communications, quantum technology, base stations, and artificial intelligence—before releasing its findings.[47]

The institute observed that, despite the sanctions levied on Huawei Technologies by the United States in 2019, China has maintained a leading position by prompting its state-controlled enterprises and academic institutions to pursue 6G technologies. China dominates the global patent filings for 6G, accounting for 40.3 percent, followed by the US with 35.2 percent, and Japan with 9.9 percent.

The potential benefits of influencing standards are vast, including tangible financial gains from licensing fees potentially amounting to billions of dollars annually, as well as the more abstract advantage of influencing technology usage.[48] Rivalry around

46 https://www.electronicsweekly.com/news/business/china-leads-6g-patents-2021-09/

47 https://www.gizmochina.com/2021/09/16/china-accounts-for-40-of-6g-patent-applications-with-most-of-them-being-filed-by-huawei-survey-reveals/

48 https://www.wsj.com/articles/where-china-dominates-in-5g-technology-11551236701

standards will continue across both formal and de facto spheres, employing regulatory measures and market power, with no immediate resolution in sight.[49]

This tension indicates that technological globalisation is at a critical inflexion point. This is particularly evident in the fierce competition witnessed in the establishment of 3G, 4G, and 5G standards. Subsequently, setting standards has emerged as a critical route to global authority and influence. However, as China's technology sector burgeons, it will persistently challenge the standard-setting process including US dominance, presenting new prospects for economic growth through emerging technologies.

The failure to reach a consensus on a shared standard would escalate the internet decoupling trend to a new level. Currently, global markets for digital hardware are already experiencing fragmentation, with both China and the West establishing de facto barriers for vendors from each other in their respective home markets. The concerns around national security have intensified due to the widespread adoption of mobile internet and the ongoing tech rivalry between China and the US. This division in markets is expected to deepen, distinguishing between those dominated by Huawei and those excluding Chinese vendors from core functions.

As the commercial landscape becomes more fragmented, the motivation to establish global standards is likely to diminish over time. In the worst-case scenario, consumers may eventually require different smartphones for various regions, and companies might need distinct devices for the emerging IoT. IoT devices designed for use in the US or the EU, for instance, would be incompatible with networks following a Chinese standard. This could result in the need for costly device replacements or complicated modifications and workarounds.

Direct government coordination or identification of strategic standards priorities might inadvertently lead to the establishment of suboptimal standards, stimulate unfair tactics, and risk fracturing standards that ought to remain global. Thus, it is crucial for democracies such as Australia and India to actively engage in the process of standard-setting to maintain their competitiveness and advantages within the dynamic landscape of technology and its governing norms.

Given these dynamics, India and Australia must take a more active role in promoting a democratic model for emerging technologies including 6G, guided by international standards. Collaborative efforts for open and secure technological standards with allies will be crucial to avoid a simplistic US-China dichotomy, thereby enhancing the effectiveness of their implementation. In the forthcoming decades, the Indo-Pacific region will see a substantial increase in digital activities. The ability of Australia and

49 “Hologram wars: The race to 6G, Politico, https://www.politico.eu/article/6g-race-eu-united-states-china/.

India to transact within these digital economies and infrastructure will depend heavily on their capacity and transparent, equitable, and open digital rules.

The optimal time to bolster Indo-Australian competitiveness in future technological innovation is well before a technical contribution advances to the global standards stage. The journey begins in research and development laboratories where ideas and proposals for standards originate. To maintain global competitiveness, efforts should predominantly target the initial phases of innovation, emphasising support for research and development, domestic commercialisation, deployment, and nurturing the next generation of technical talent.

Both countries should advocate for good governance within standards-setting organisations, ideally in collaboration with like-minded nations. The collaborative initiative between India and Australia can be a positive stride toward enhanced specialisation and policy alignment. The primary goal of the initiative should be to foster closer collaboration between the two nations concerning the development and adoption of technological standards.

Additionally, it aims to streamline the exchange of statistical data, ultimately facilitating trade, boosting interoperability, and creating a business-friendly environment for companies. Jointly, they can play a crucial role in advancing innovation and optimisation in the global telecommunications market to ensure the telecommunications market remains safe, resilient, and competitive.

4.2 India

Historically, developing and least-developed countries around the world have been dependent on foreign mobile communication technology, due to a lack of Intellectual Property Rights (IPRs) over technical standards. For instance, until recently, advanced countries and regions such as the US, Europe, and Japan were the primary developers and deployers of global mobile standards such as 3G and 4G. 5G was the first occasion where India has been able to participate in the development of mobile standards.

TSDSI's engagement in SDOs like 3GPP and ITU-R is a strategic move that holds significant potential in shaping underlying policies and practices. These initiatives play a pivotal role in allowing India to exert influence on global policy developments, providing a boost to domestic firms and fostering innovation. This active participation empowers Indian companies to invest in targeted R&D efforts, enhancing their competitiveness on a global scale.

Aligned with broader policy initiatives and recognising the immense potential of 6G outlined in the vision document, the Indian government is actively working to establish a comprehensive ecosystem for the development and deployment of 6G networks. To propel India towards a leadership role in 6G, the Centre of Development of Telematics

(C-DoT), the R&D arm of the Department of Telecommunications (DoT), has been allocated Rs 550 crore for the fiscal year 2023-24. As part of its self-reliance goals, the government has also recently announced a 5G test bed project for startups and industry players in India. This initiative provides a complete test bed for testing and validating equipment for 5G services, offering valuable support to startups and industry participants.

As TSDSI progresses, it intends to direct research in India toward fulfilling the objectives outlined in its 6G vision statement. This includes collaborating with global standard bodies to align efforts and innovating to create technologies promoting personalisation and services' localisation. TSDSI's 5Gi standard has been formally merged with the 3GPP 5G standard and implemented into the 3GPP Rel-17 NR specifications. 3GPP RAN approved two Rel-17 Change Requests (CRs) that enable Pi/2-BPSK (the new Phase Shift Keying modulation technique) waveform with filtering to be implemented in the 5G Networks. It is one of the important requirements for improving cellular and IoT connectivity in rural India.

ITU-R has initiated work on developing a recommendation on the vision for IMT for 2030 and beyond. TSDSI is contributing towards the IMT 2030 work which will drive the direction of 6G technologies. The focus is on four key technology pillars:

1. Technologies that aid the development of a Ubiquitous Intelligent Mobile Connected society.
2. Technologies to Bridge the Digital Divide.
3. Support technologies that can Personalise /localise services.
4. Support technologies that can mimic real-world data ownership and hierarchies.

With 6G, the Indian government constituted a task force to identify pathways to contribute to the standard-making process.[50] The DoT announced the formation of a 22-member technology innovation group to develop indigenous 6G technology in 2021. After the formation of the group on 6G, India's Minister of Communications Ashwini Vaishnaw said: "We will have designed-in-India telecom software for running the networks, manufactured-in-India telecom equipment, served-in-India telecom networks, which can go global."[51]

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[50] https://dot.gov.in/circulars/constitution-task-forces-under-technology-innovation-group-6g

[51] https://www.indiatoday.in/technology/news/story/india-will-deploy-6g-technology-by-2024-says-communication-minister-ashwini-vaishnaw-1880318-2021-11-24

Recently, Vaishnaw said that Indian scientists, engineers, and academicians have acquired 100 patents for 6G technology.[52] DoT Secretary K Rajaraman, said, "We are in a situation where 6G standards are not there. So, we are trying to be part of the standards-making process."[53] Devusinh Chauhan, the Minister of State for Communications, also affirmed that India wants to take a leadership position and contribute to global standards.[54]

In the process of contributing to the global 5G standards development within entities such as the 3GPP and ITU, India as a sovereign state has accrued significant experience now.[55] India has made inroads into the global standard-making process through 5Gi to foster domestic manufacturing growth and keep an eye on national security considerations. India's regulatory framework around technologies has been in tandem with these aims, largely furthering protectionism.[56]

5Gi stirred controversy as domestic telecom operators and equipment vendors opposed its mandatory adoption, due to interoperability and cost issues. Opposition from the industry forced 5Gi to merge with global standards of 5G.[57] The development of India's 5Gi standard showed India's capability to contribute to global technical standards.

Concurrently, Indian corporations have fostered core expertise within specific domains. During this progression, a comprehensive understanding of the Standards Development Lifecycle, particularly the one pursued within 3GPP encompassing workflow and procedural aspects, has been gained. Tejas Network with Sanmina Corp and Reliance Jio is also developing its own 5G network equipment and software solutions.[58]

They are paving the way for a similar model to be employed in future 6G rollouts. Through the capitalisation of this acquired knowledge, India holds the potential to actively contribute to the 6G standards development across international institutions like the 3GPP, ITU, IEC, IEEE, and one M2M, among others. This proactive participation

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52 https://www.communicationstoday.co.in/indians-acquire-100-patents-for-6g-technology/

53 https://economictimes.indiatimes.com/industry/telecom/telecom-policy/india-aiming-to-help-develop-6g-standards-dot-secretary/articleshow/95749440.cms#:~:text=%22We%20are%20in%20a%20situation,secretary%20K%20Rajaraman%20told%20ET.

54 https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1763370

55 https://dot.gov.in/sites/default/files/Bharat%206G%20Vision%20Statement%20-%20full.pdf

56 https://thewire.in/tech/what-should-india-hope-to-get-out-of-its-5gi-standard-experiment

57 https://m.economictimes.com/industry/telecom/telecom-news/indias-5gi-to-be-merged-with-global-standard/articleshow/88263911.cms

58 https://www.lightreading.com/5g/ril-strengthens-local-tech-capabilities-for-indias-5g-race/d/d-id/775914

could amplify India's presence within the global standardisation arena and ensure a substantial volume of pivotal innovations originate from the nation.

In its 6G vision document, the government has stated that the forthcoming 6G technologies, anticipated to come into fruition and exert substantial influence in the subsequent decade, will foster ubiquitous instantaneous communication, pervasive intelligence, immersive experiences, and an Internet of Things & Senses.[59]

Further, 6G is projected to amalgamate terrestrial, aerial, and maritime communications into a resilient network that offers increased speed, reliability, and the capacity to support an array of devices with ultra-low latency requirements. To fulfil the objectives delineated by the task force and the vision document, the formulation and execution of policies that foster technological innovation and provide incentives for research and development investments are of paramount importance.[60] One of the crucial strategies to accomplish this involves active participation in, and exploitation of, standards development due to its substantial economic, technological, and competitive benefits for stakeholders.

4.3 Australia

About the impending advent of 6G, Australia is yet to initiate significant measures.[61] It is therefore imperative that the Australian government, in collaboration with its partner agencies, particularly the Australian Cyber Security Centre (ACSC), formulate and implement a robust Standards Engagement Plan. This plan should include active participation in standard-setting organisations such as 3GPP. The engagement strategy should be delineated with explicit, prioritised outcomes and deliverables in alignment with broader interests. These should encompass amplifying Australia's influence within these key organisations and contributing to the evolution of 6G and subsequent technologies along with their associated network equipment security assurance schema.

Engagement and cooperation at the international level are critical for Australia to facilitate a trustworthy foundation, thereby enhancing the security of 6G networks and the technologies developed upon them in a reliable, secure, resilient, and transparent manner.[62] The concept of intelligent mining, for instance, has transitioned from an aspirational goal to an immediate reality.

Given the scale of Australia's mining industry, the development of a smarter, more efficient and safer operating model is a necessity. Australia possesses the potential to define the standards for 5G technology development within the mining sector and

59 https://dot.gov.in/sites/default/files/Bharat%206G%20Vision%20Statement%20-%20full.pdf
60 https://dot.gov.in/sites/default/files/Bharat%206G%20Vision%20Statement%20-%20full.pdf
61 https://telsoc.org/sites/default/files/journal_article/340-article_text-3277-3-10-20201221.pdf
62 https://telsoc.org/sites/default/files/journal_article/340-article_text-3277-3-10-20201221.pdf

propagate these standards globally. Huawei acknowledged Australia's leadership within the mining industry and envisioned developing local 5G mining solutions in conjunction with leading Australian developers.

Despite initial plans to establish a global mining R&D centre in Australia, Huawei has since aborted this substantial research and development investment following the 5G exclusion.[63] Australia remains committed to supporting and fostering international mechanisms that encourage stability. They aim to work with partners voluntarily to deter and respond to unacceptable behaviour in cyberspace. Australia participates in forums such as the ISO and the ITU, which are pivotal in developing international standards that contribute to a more secure cyberspace for all nations. Promoting awareness and building capacity helps ensure the meaningful use of technology and will ultimately enhance our collective cyber resilience, thereby delivering direct benefits for Australia.[64]

4.4 Opportunities for India-Australia Collaboration

India–Australia relationship is rapidly becoming one of the most important pillars of the Indo-Pacific. The collaboration between India and Australia in developing 6G and advanced technologies is not only a technological initiative but also holds strategic significance aligning with the security interests of the broader Indo-Pacific region. Beyond delivering faster network speeds, their joint efforts will exert influence in setting 6G standards at the ITU, a space currently contested by China.

The era of independent pursuits is behind us; collaborative endeavours are the key to unlocking the geotechnological imperatives of 6G. Critical technologies will be instrumental and by shaping technology standards, establishing connections with trusted partners, and leveraging its position as an emerging leader in science and technology, India can contribute significantly to the region's stability.

The increasingly crucial role of standards has already prompted increased cooperation among Indo-Pacific nations, such as the Indo-Pacific Economic Framework (IPEF), which seeks to improve trade standards, govern the digital economy, and enhance the security and resilience of supply chains.[65] Similarly, the QUAD aims to enhance cooperation on emerging technologies in the Indo-Pacific region.[66]

Effective use of technology will be a determining factor in shaping the geopolitical landscape globally as well as in the Indo-Pacific. As nations align along regional power axes, a cooperative approach will be key to ensuring that democratic norms are upheld

63 https://www.reuters.com/article/uk-huawei-tech-australia-redundancies-idUSKCN26C39H
64 https://telsoc.org/sites/default/files/journal_article/340-article_text-3277-3-10-20201221.pdf
65 https://www.whitehouse.gov/briefing-room/statements-releases/2022/05/23/statement-on-indo-pacific-economic-framework-for-prosperity/
66 https://pib.gov.in/PressReleasePage.aspx?PRID=1827892

in the era of rapid technological evolution. India-Australia will be central to this cooperation and can drive practical outcomes from QUAD and play a powerful role in setting international technology standards, especially in areas where they excel, such as AI, computing and energy technologies.

Collaborating with the United States and Japan is particularly advantageous for India and Australia, given the valuable expertise these nations have gained through extensive research and development in 5G technology. Such partnerships would facilitate knowledge exchange and mutual benefits in navigating the complexities of developing and deploying 6G.

Another crucial aspect is the need to formulate and standardise policies and international norms related to the hardware required for 6G technology. During the Quad Leaders' Summit in 2021, they introduced the Quad Principles on Technology Design, Development, Governance, and Use. These principles underscore the importance of collaborative approaches involving multiple stakeholders from the industry to develop international standards to promote compatibility, interoperability, and inclusivity.

The Quad countries asserted that the design, development, and governance of critical and emerging technologies should be guided by their shared democratic values and a respect for universal human rights. They further underscored their commitment to establishing an open, accessible, and secure technology ecosystem built on mutual trust and confidence.

QUAD has initiated the Critical and Emerging Technology Working Group and has disseminated joint statements about the design, development, governance, and usage of technology. At the Quad Summit held in Tokyo, an array of initiatives were introduced, one of which included the formal inauguration of fellowships for exemplary STEM graduate students, alongside a novel memorandum of cooperation focusing on 5G Supplier Diversification and Open RAN. Moreover, the Quad member countries proposed several innovative initiatives such as the Indo-Pacific Partnership for Maritime Domain Awareness, the Quad Investors Network, the Quad Cybersecurity Partnership, and the International Standards Cooperation Network, which aims to facilitate information sharing on technical standards.[67] The Quad Critical and Emerging Technology Working Group will pursue five lines of effort[68]:

67 https://www.whitehouse.gov/briefing-room/statements-releases/2022/05/23/fact-sheet-quad-leaders-tokyo-summit-2022/

68 https://www.whitehouse.gov/briefing-room/statements-releases/2021/03/12/fact-sheet-quad-summit/

1. Develop a statement of principles on technology design, development and use
2. Facilitate coordination on technology standards development, including between our national technology standards bodies, and working with a broad range of partners
3. Encourage cooperation on telecommunications deployment, diversification of equipment suppliers, and future telecommunications, including through close cooperation with the private sector and industry
4. Facilitate cooperation to monitor trends and opportunities related to developments in critical and emerging technology, including biotechnology
5. Convene dialogues on critical technology supply chains

India and Australia have shown an inclination to collaboratively strengthen mutual interests across multiple international forums. Their focus is primarily on the development of international standards, norms, and frameworks about cyberspace and critical, emerging technologies. This partnership is particularly important to the development and standardisation of the 6G as Australia and India have taken contradictory stands in the past.

The bilateral interactions between the two nations extend beyond the Australia-India Economic Cooperation and Trade Agreement (AI-ECTA), within the wider Comprehensive Strategic Partnership framework[69] Key mechanisms facilitating this collaboration include cyber policy dialogues and the Australia-India Cyber and Critical Technology Partnership (AICCTP).[70]

India aims to entice partners by leveraging its substantial market size and highly skilled IT workforce, offering incentives for investment and a first-mover advantage. As 6G relies on Terahertz communication, private entities will play a crucial role.

The foundation for a partnership in critical and emerging technologies has already been laid by the AICCTP, creating a positive momentum. Further investment in areas of shared interest can boost regional collaboration in crucial domains like 6G, artificial intelligence, quantum computing, space technology, and critical minerals. The Australian government should leverage its strengths in research and development, as well as training and education. To enhance collaboration, knowledge exchange programmes should be strengthened, involving researchers from Indian universities and think tanks undertaking PhDs, research, and think-tank fellowships in Australia.

69 https://mea.gov.in/bilateral-documents.htm?dtl/32729/Joint_Statement_on_a_Comprehensive_Strategic_Partnership_between_Republic_of_India_and_Australia

70 https://india.highcommission.gov.au/ndli/AICCTP.html

While the international community recognises Indian talent, India must translate these partnerships into retaining and enhancing talent domestically, particularly to drive advancements in 6G. To reinforce investment in projects and technology aligned with its commitment to a free and open Indo-Pacific, achieving technological evolution will require a coordinated effort involving governments, industry, private capital partners, and civil society.

In addition to developing Indian talent, such opportunities support the foundation of trusted technology partnerships. The Russia-Ukraine and Palestine-Israel conflict has underscored the indispensability of trusted relationships. With growing geopolitical tension, both these countries will need trusted partnerships on which they can rely to provide the goods and materials through secure supply chains. In light of national security concerns, Australia and India have shown sensitivity and proactivity.[71] For instance, Australia was the first country to exclude Huawei and ZTE from its 5G rollout, setting a precedent for similar decisions worldwide.[72]

Moreover, both countries have committed to a new cyber framework that encompasses a five-year plan for digital economy collaboration, cybersecurity, and key and emerging technologies. To enhance this technological partnership, Australia has established a new Consulate-General and a Centre of Excellence for Critical and Emerging Technology Policy in India.[73]

These establishments aim to consolidate ties with India's innovation ecosystem and foster the responsible development of critical technologies. Australia and India may discover mutual interests, especially in advanced and high-tech manufacturing. As India aims to establish itself as an alternative manufacturing hub, Australian industries stand to gain from improved access to India's abundant pool of cost-effective labour and technical talent.

Both Australia and India are moving in a positive direction by not exclusively concentrating on the standards bodies themselves which could overlook valuable prospects for future contributions in standards-setting. This partnership needs to focus on technological innovation necessitates an integrated policy approach to foster the STEM talent pool and advanced R&D capabilities. Their collaborations are directed

71 Huawei and ZTE handed 5G network ban in Australia; available at: https://www.bbc.com/news/technology-45281495

72 Common values, shared threats in India-Australia cyber security ties, available at: https://indianexpress.com/article/opinion/columns/common-values-shared-threats-in-india-australia-cyber-security-ties-7888890

73 https://www.foreignminister.gov.au/minister/marise-payne/media-release/strengthening-our-technology-partnership-india#:~:text=Australia%20is%20strengthening%20our%20technology,to%20be%20based%20in%20India.

towards nurturing the roots of innovation, rather than focusing primarily on the latter stages of the journey at the standards-setting bodies.

While endorsing standards-setting initiatives is crucial, fostering true competitiveness requires empowering firms to take a leadership role within standard-setting bodies. This collaborative effort would bring mutual benefits to both India and Australia, as well as the broader Indo-Pacific regions. Additionally, they can enhance cooperation in space security governance and actively promote policy discussions in the Indo-Pacific on topics such as AI, standardisation, data security, and ethics.

Chapter 5

Conclusion and the Way Forward

The evolution of telecommunication standards, as seen in organisations like 3GPP and IEEE, has been instrumental in enhancing the accessibility and affordability of communication devices and services. These standards not only drive innovations but also provide economies of scale to manufacturers. The report extensively examines the standardisation landscape, motivations, challenges, and the role of India and Australia in the context of 6G, shedding light on potential economic impacts, geopolitical considerations, and the interactions shaping these standards. In the broader context of technological innovation, the focus on standardisation gains prominence, particularly considering the standardisation gap between developed and developing nations.

The historical dominance of Western actors is evolving, with Asian players, notably China, asserting influence. However, the geopolitical tensions, especially between the United States and China, pose challenges and raise concerns about potential fragmentation in 6G standards. This geopolitical backdrop underscores the report's emphasis on a collaborative and strategic approach, advocating for active engagement by India and Australia in international standard development processes. Their participation is crucial for shaping global standards, promoting good governance within standard-setting organisations, and championing a democratic model for emerging technologies, including 6G. As the Indo-Pacific region witnesses increased digital activities, the chapter underscores the urgency for these countries to play a leading role in standards-setting, ensuring a resilient, open, and secure digital future.

In the above context, the next section provides recommendations for policymakers, industry players, and civil society. Looking ahead to the future of wireless communication, the recommendation offers valuable insights to guide collaborative and open 6G standards, aligning with global interests and contributing to the advancement of India and Australia in the telecommunication space.

Recommendations

- **Nurturing Consensus-Based Standardisation Processes:** Considering the dynamic nature of the standardisation environment, discussions may be more effective if they shift focus from China and potential responses to its involvement. Instead, emphasis should be placed on preserving the overall integrity of the standardisation framework. It is crucial to ensure that international standardisation processes continue to operate according to established rules, with relevant oversight and accountability frameworks in place. No single actor, regardless of power and influence, should have the ability to manipulate the system.

Both these countries should promote and strengthen consensus-based processes involving a diverse community is essential for creating effective standards. If only a few actors contribute, the likelihood of successful implementation and diverse global needs will diminish. Both India and Australia can draw a few lessons from China's strategy, including supporting the industry, promoting standards awareness and education, and allocating resources. This approach applies not only to standardisation work but also to the broader technological space, ensuring ongoing competitiveness.

- **Shaping Domestic Innovation Ecosystems for 6G:** For jurisdictions like India and Australia aiming to develop their domestic innovation ecosystems for 6G, focusing on advocacy efforts is crucial. Both countries should establish policies facilitating the participation of domestic firms and institutions in international SDOs or industry consortia. This approach enhances exposure to standard-setting activities, allowing local firms to leverage their technologies in the global value chain. Historical perspective on standards development and the advantages and disadvantages of various standardisation modes provide several arguments favouring the active participation of jurisdictions like India in international standard development processes.

  Lessons from jurisdictions attempting protectionist policies or unilateral standard development highlight the success of engaging in international fora. It is the only viable process through which local companies and domestic firms can influence the direction of standardised technologies, voice their opinions, and present special requirements. This active participation is crucial for guiding new entrants in identifying specific research gaps in technology development and focusing their R&D efforts to address them. Apart from economic considerations, viewing standardisation from a policy perspective is also important.

- **Strategic Engagement in the Indo-Pacific to Enhance Competitiveness:** Both nations should prioritise establishing and nurturing an environment of symbiosis among standards organisations, industries, and academia. The current approach in both countries, while noteworthy for its strengths, appears fragmented and lacks the cohesiveness required for optimal results. This could be facilitated by structured dialogue platforms, regular exchanges, and targeted programmes designed to stimulate innovation and knowledge transfer. This strategy for standards development can bring about increased coherence and alignment in the efforts of all stakeholders.

Such a strategy should take into account the national objectives, industry capabilities, and evolving global trends in telecommunications. Further, policymakers should strive to provide clear and consistent policy directions to foster a conducive environment for technological innovation. Regulatory clarity will instil confidence among industry stakeholders, thereby attracting investment and facilitating the rapid and consistent deployment of emerging technologies.

Moreover, Australia and India should actively build strategic engagement with regional standards organisations within and across the Indo-Pacific. By leveraging the combined expertise and support from different standard-setting bodies, both countries can significantly enhance their influence and competitiveness in the realm of emerging technologies. This engagement may be broadened, for instance, by charting the critical standards that influence digital trade and the emergence of novel technologies in major markets. Opportunities could also be explored for capacity-building initiatives designed to strengthen the role of regulators and officials in the creation and application of standards. Whenever feasible, these endeavours should collaborate with regional standards bodies, harnessing their unique insights and capabilities.

- **Toward Coherent Policies for Innovation in 6G:** To cultivate a more comprehensive understanding of the interrelated domains of standards, digital trade, and internet governance, Australia and India should establish a platform that fosters robust dialogue. This platform should bring together representatives from the standards community, the digital trade industry, relevant government departments, and academia. It is essential to create an environment where knowledge can be exchanged freely, best practices shared, and unique challenges collaboratively addressed. Through regular forums, symposiums, and interactive sessions, stakeholders can build a shared understanding of the technological landscape. This dialogue can spotlight the role of standards in emerging technologies, provide updates on the latest developments in the sector, and discuss the challenges and opportunities posed by digital trade.

  Concurrently, policymakers and industry representatives should strive for greater policy coherence and adopt synergistic approaches to address the complex and evolving challenges in these domains. The policies and regulations concerning standards, digital trade, and internet governance should be aligned with the shared objectives of promoting innovation, competitiveness, and inclusivity in the digital economy.

Additionally, government departments should collaborate closely with industry and academia to ensure the regulatory environment is responsive to technological advancements and supports the growth and international competitiveness of their digital sectors. Informed, forward-looking policies can pave the way for robust digital trade, efficient standard-setting, and effective governance of the Internet. By fostering cross-disciplinary dialogue and promoting policy coherence, Australia and India can navigate the intricacies of this evolving landscape, bolster their digital economies, and influence the future trajectory of global development of telecommunication standards.

- **Building Capacity and Awareness in Telecommunications Standards:** India and Australia should prioritise the capacity building of domestic firms and increase awareness of significant elements such as Standard Essential Patents (SEP), Intellectual Property (IP), and the paramount role of standards. They should aim to cultivate an environment conducive to innovation and advancement through collaborative and reciprocal cooperation. This joint effort can enhance understanding, promote active participation in standards development, and ultimately foster a competitive edge for domestic firms in the global technology marketplace.

  Both India and Australia should increase investment in wireless R&D across universities, labs, and industry consortia. In addition to this, they must prioritise investment in its future intellectual reservoir, specifically within the context of STEM education. It is crucial to foster the growth of STEM skills early in a student's educational journey, thereby preparing them for further study and eventual employment within STEM disciplines.

  Without a constant influx of new talent, wherein successive generations pursue careers in telecommunications-related industries or associated research or government institutions, the United States may encounter significant challenges in maintaining its leadership position within the sphere of wireless innovation.

For any further queries, please reach out to Asheef Iqubbal (aql@cuts.org), Senior Research Associate, CUTS International.

CUTS International

D-217, Bhaskar Marg, Bani Park, Jaipur 302 016, India
Ph: 91.141.228 2821, Fax: 91.141.228 2485
Email: cuts1@cuts.org, Website: www.cuts-international.org
Also at Delhi, Kolkata and Chittorgarh (India); Lusaka (Zambia); Nairobi (Kenya); Accra (Ghana); Hanoi (Vietnam); Geneva (Switzerland); and Washington DC, (USA).