Study Report

Development of Best Practice Guides for 5G Ecosystem Development in ASEAN

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1. OVERVIEW

1.1. What is 5G?

5G is the next generation of mobile standards being defined by the ITU. IMT-2020 (5G) is a name for the systems, components, and related elements that support enhanced capabilities beyond those offered by IMT-2000 (3G) and IMT-Advanced (4G) systems.

According to the ITU, 5G is an opportunity for policy-makers to empower citizens and businesses. 5G will play a key role in supporting governments and policy-makers in transforming their cities into smart cities, allowing citizens and communities to realize and participate in the socio-economic benefits delivered by an advanced, data-intensive, digital economy.

5G promises to deliver improved end-user experience by offering new applications and services through gigabit speeds, and significantly improved performance and reliability. 5G will build on the successes of 2G, 3G and 4G mobile networks, which have transformed societies, supporting new services and new business models. 5G provides an opportunity for wireless operators to move beyond providing connectivity services, to developing rich solutions and services for consumers and industry across a range of sectors – and at affordable cost. 5G is an opportunity to implement wired and wireless converged networks, and offers in particular opportunities in integrating network management systems.

5G is also expected to increase data rates dramatically and reduce latency compared to 3G and 4G. 5G is expected to significantly reduce latency to below 1ms, suited to mission-critical services where data are time-sensitive. Its high-speed capability means 5G networks can provide a range of high-speed broadband services and offer an alternative to last-mile access such as FTTH or copper connections. [Table 1]

It should be noted that the above 5G networks can only be realized by introducing (1) network slicing, (2) new wireless technology, and (3) mobile edge computing technology, etc.

Table 1. Evolution of mobile networks

	1G	2G	3G	4G	5G
Approximate deployment date	1980s	1990s	2000s	2010s	2020s
Theoretical download speed	2kbit/s	384kbit/s	56Mbit/s	1Gbit/s	10Gbit/s
Latency	N/A	629 ms	212 ms	60-98 ms	< 1 ms

1.2. Socio Economic Implication of 5G [6]

Despite the global pandemic and associated economic constraints, new 5G networks continue to be launched. Those launches so far have been concentrated for the most part in developed countries. However, developing markets are now entering the 5G era, even if the scale is minimal.

It is recognized that there is a few third party studies that have looked into the economic impact of investment in 5G. Nevertheless, it is possible to draw upon some third party forecasts to estimate the impact that 5G could have on economic output.

One report estimates that 5G will underwrite USD 12.3 trillion of global economic output by 2035, with the greatest growth in sales activity coming from manufacturing because of an anticipated increase in spending on 5G equipment. This is followed by sales growth in the ICT sector driven by higher expenditure on communications services. Investment in the value chain is expected to generate a further USD 3.5 trillion in output and provide support for 22 million jobs by 2035.

Other reports have also indicated significant economic benefits and productivity enhancements resulting from investment in 5G networks. Such estimates set out to provide a quantification of the benefits of 5G while assuming ideal investment conditions. The true economic benefit for each country will vary depending upon market structure and the availability of digital and supporting economic infrastructure.

Policy-makers may consider undertaking their own economic assessment of the commercial viability and economic impact of 5G networks.

It is also noted that many 5G initiatives and announcements on 5G pilots, trials as well as commercial deployments from national levels to regional and global levels are already taken place. Globally, it forecasts operators will spend 80% of sector capex on 5G networks over the next five years, reaching 45% population coverage. But, there are pronounced regional differences and significant pressure to improve cost efficiency for laying and operating those networks. More importantly, there is some way to go before the investment case for operators can be made robust and before any large-scale commercial deployment can commence.

Until the investment case for 5G is demonstrable, industry and policy-makers may consider approaching 5G investment with caution and should continue to enhance the availability and quality of the existing 4G networks.

1.3. ASEAN 5G Ecosystem Development

Developing 5G is of significance to the economic growth of ASEAN Member States as 5G will be the most important part of the infrastructure for the digital economy. At the ASEAN Digital Ministers' Retreat in March 2019 in Phuket, Thailand, the Ministers stressed the importance of 5G as essential platform for Digital Economy.

This study aims to deliver a comprehensive approach to assisting ASEAN Member States in the 5G introduction and implementation through a both in-country and cross-border (regional) best practice guides for 5G ecosystem development addressing both supply-side and demand-side objectives.

The guided issues will focus on, but not limited to, concepts, features and technological platforms, and potential applications of 5G technology in the context of the 4th Industrial revolution; framework and action plan for 5G deployment in ASEAN; measures and recommendations focusing on platforms for 5G deployment, 5G use-cases development, 5G testing, piloting and operating; resources mobilization; case studies and best practices sharing among ASEAN Member States (AMS) and with countries outside ASEAN.

2. PROPOSED GUIDELINES AND RECOMMENDATION FOR 5G ECOSYSTEM DEVELOPMENT IN ASEAN

2.1. Policy & Regulations

2.1.1. Spectrum allocation & releasing

The development of 5G technology that provides new services requires a large and enough bandwidth to deploy 5G and all of its applications in which the existing 2G, 3G, 4G frequency bands could not meet. All three areas include high frequency, mid frequency, and low frequency are essential and is a prerequisite for the deployment of 5G networks. Frequency bands below 1 GHz are suitable for the implementation of 5G services with widespread coverage across urban, suburban and rural areas and help support Internet of Things (IoT) services. Frequency bands from 1 GHz to 6 GHz harmonizes the development of coverage and capacity for 5G networks. This frequency bands are suitable for eMBB and uRLLC applications. The frequency bands above 6 GHz are one of the important frequency bands to deploy ultra-high broadband speeds with a focus on mmWave range. However, this frequency band has the disadvantage that the coverage area is limited due to the high propagation loss characteristics.

5G deployments in new bands such as C-band or mmWave (i.e. 3500 MHz, 26 GHz) will use TDD technology instead of FDD technology like 2G, 3G and 4G networks. Therefore, frequency coordination between 5G networks will need to take into account not only frequency parameters but also spatial, temporal and TDD data frame parameters. Besides, differences in frequency band planning options and timing of licensing frequency bands between countries may have significantly impact on the development of the 5G device ecosystem and may cause interference problems in border areas in which regulatory agencies need to solve to ensure that the 5G services deployment are smooth and meet the usage requirements of users.

By using a combination of different frequency bands, 5G networks will be able to cover a wide range of areas, from urban areas to suburban and rural areas. Seamless 5G connectivity anytime, anywhere for all types of services can be achieved with a dense network of base stations. In other words, the number of 5G base stations, especially those operating at high frequencies (e.g. mmWave band) will increase significantly. This

could create public concerns about the impact of millions to billions of 5G wireless connections on human health and the environment. Therefore, the regulator should review national regulation on radio frequency exposure limitation to update the latest guidelines of international organization such as ICNIRP (The International Commission on Non-Ionizing Radiation Protection) on this matter

Summary of spectrum regulatory recommendations to AMS:

- ASEAN Spectrum Management Sub-Working Group (SSM) should discuss and develop the workplans and specific study items to promote the harmonization plan of new potential band for 5G such as 700 MHz, 1500 MHz, 2600 MHz, 3500 MHz, 4900 MHz, 26 GHz, 43 GHz, 71 GHz within ASEAN.
- ASEAN regulators should issue specific plans and/or roadmaps to make the new frequency bands available for 5G use as soon as possible in which focus on the dealing with the removal of Incumbent systems in the key bands including but not limited to 700 MHz, 3.5 GHz and other bands for 5G use.
- The frequency planning for 5G should take into account the needs of not only public use but also private/local use.
- The border frequency coordination needs to continue to focus on minimizing the risk of edge interference between neighboring countries' 5G networks due to differences in frequency band planning (e.g. FDD vs TDD) and the designation of TDD synchronization time frames of 5G networks.
- Based on the standards, recommendations of the international organization on the health effects of radio radiation including 5G on the human body, ASEAN spectrum regulators should have adequate instructions and information campaign for psychological assurance of the concerned ASEAN citizens.

2.1.2. Network & infrastructure:

Based on the outcomes of studies and feedbacks of international experts and those from ASEAN countries, the study proposes to focus on the following issues in regards to network and infrastructure for 5G ecosystem development in ASEAN:

(1) 5G Base Station

In the case of 2G, 3G and 4G, base stations can cover a range of several kilometers to tens of kilometers due to the use of low frequency bands, while 5G base stations cover only tens to hundreds of meters. Therefore, a large number of base stations needs to be set up in order to cover area of the same size.

Defined, explicit and nationally consistent planning approval processes for mobile base stations, have the potential to avoid lengthy delays in network deployment. Mechanisms that reduce bureaucratic inefficiencies, including exemptions for small installations, colocations or certain site upgrades, 'one-stop shop' licensing procedures and tacit approval can support infrastructure deployment. Similarly, improving access to government-owned land and buildings may also encourage deployment.

(2) Sharing of Network infrastructure

ASEAN ICT regulators should review and modernize the current regulations to encourage joint investment in 5G networks and active/passive sharing of telecom infrastructure in order to rapidly deploy 5G in their countries.

The sharing of network infrastructure will bring benefits to telecommunications businesses and the society, thereby opening up potential for digital society and digital economy. Appropriate policies on network and infrastructure deployments will help remove administrative barriers and accelerate the rollout of 5G networks.

While it may at times be advantageous for mobile operators to share infrastructure, network deployment remains an important element of competitive advantage in mobile markets. Any sharing should therefore be the result of commercial negotiation, not mandated or subject to additional regulatory constraints or fees. The regulatory framework of a country should facilitate all types of infrastructure sharing arrangements, which can involve the sharing of various components of mobile networks, including both passive and active infrastructure sharing. Infrastructure sharing agreements should be governed under commercial law and as such, subject to assessment under general competition law. Access to government-owned trunk assets should be available on non-discriminatory commercial terms, at a reasonable market rate.

It is a manifestation of the use of the principle of market competition.

In parallel with the formulation of 5G infrastructure development policies, ASEAN ICT regulators should quickly come up with policies to support backbone networks to handle 5G's ultra-high speed data traffic. The more rapid the deployment of optical fiber networks, the more rapid the expansion of 5G networks will be.

(3) Getting rid of the legacy type components

In considering 5G development, it is necessary to actively work on getting rid of the legacy type components that typically become obstacles to development. In this sense, the introduction of O-RAN/V-RAN is an urgently needed initiative which ASEAN ICT regulators should take into account. By promoting O-RAN/V-RAN, network operators will be able to configure their networks with terminals from multiple vendors, which will promote competition among vendors and lead to lower network prices.

In developed countries, the following issues are being studied.

- Open RAN (O-RAN) leverages off the separation of hardware and software in the RAN, a technology known as vRAN (virtualized RAN), which is also supported by telco equipment manufacturers. The idea is that the hardware should then become cheaper as it will be produced by "white box29" network equipment manufacturers.
- Because Open RAN is standardized there should be interoperability between the various hardware vendors, and hardware vendors should be easier to swap out. Alternatively, multiple vendors are possible in the RAN for hardware vendor diversification. Having said the above, it remains to be seen how easy it is to swap out a software vendor. There is a risk that if operators swap out traditional vendors, that the replacement vendors may not have all the features needed.
- In the race to 5G market launch, there has also been patent war, and the traditional vendors hold the majority of key patents. This means a displaced vendor will hold onto their Intellectual Property unless the displacing vendor has a patent license agreement in place. For example, Dynamic Spectrum Sharing (DSS) is a patentable technology, while other key features such as how to manage the end-to-end QoS could also have vendor specific algorithms patented.

2.1.3. Cyber security:

Ensuring safety and security for telecommunications networks is always one of the important issues for the ICT regulators when considering allowing the deployment of new mobile technologies. From making general regulations such as safe vendor selection to avoid being too dependent on a manufacturer, equipment supplier, to specific regulations on security and safety plans for businesses construction, operation, maintenance as well as mobile users (e.g. user data privacy policies).

Based on the outcomes of studies and feedbacks of international experts and those from ASEAN countries, the study proposes to focus on the following issues in regards to cyber security for 5G ecosystem development:

- Strengthen collaboration with specialized Cyber security agencies
- Develop a framework to address cyber security issues
- Implement adequate cyber security measures
- Promote Cybersecurity Capacity Building
- Enhance Data Privacy protection

In consideration of these 5 items, the states of play in the U.S., EU and Japan are summarized as follows.

(1) Cyber security in U.S. [4] [5]

In the United States, CISA is leading the 5G cybersecurity strategic efforts.

The following document and figures have been transcribed from CISA's public documents.

The initiatives are described in the following figure.

In order to realize the above initiatives, the following examples of RISKS need to be recognized and addressed by government and industry in a cooperative manner.

i. Risks from 5G Development

CISA mentioned that the Agency is working interagency, industry, and international partners to manage the accompanying risks and challenges to 5G implementation appropriately, increasing its security and resilience at the design phase and reducing national security risk from an untrustworthy 5G network. While the deployment of 5G presents opportunities to enhance security and create better user experiences, there are among the risks that should be considered:

- **Attempts by threat actors to influence the design and architecture of 5G networks:** 5G will utilize more ICT components than previous generations of wireless networks. Municipalities, companies, and organizations may build their own local 5G networks, potentially increasing network vulnerabilities. Improperly deployed, configured, or managed 5G equipment and networks may be vulnerable to disruption and manipulation.
- **Susceptibility of the 5G supply chain due to the malicious or inadvertent introduction of vulnerabilities:** The 5G supply chain is susceptible to the

malicious or unintentional introduction of risks such as malicious software and hardware, counterfeit components, and poor designs, manufacturing processes, and maintenance procedures. 5G hardware, software, and services provided by trusted entities could increase the vulnerabilities of network asset compromise and affect data confidentiality, integrity, and availability.

- **Current 5G deployments leveraging legacy infrastructure and untrusted components with known vulnerabilities:** 5G builds upon previous generations of wireless networks and is currently being integrated with 4G LTE networks that contain some legacy vulnerabilities. Some of these legacy vulnerabilities, whether accidental or maliciously inserted by untrusted suppliers, may affect 5G equipment and networks despite the integration of additional security enhancements.
- **Limited competition in the 5G marketplace resulting in more proprietary solutions from untrusted vendors:** Despite the development of standards designed to encourage interoperability, some companies, such as Huawei, build proprietary interfaces into their technologies. This limits customers' choices to use other equipment. Lack of interoperability with other technologies and services limits the ability of trusted companies to compete in the 5G market.
- **5G technology potentially increasing the attack surface for malicious actors by introducing new vulnerabilities:** The implementation of untrusted components into a 5G network could expose communications infrastructure to malicious or poorly developed hardware and software, and could significantly increases the risk of compromise to the confidentiality, integrity, and availability of 5G data.

ii. Partnership enable 5G security and Resilience

CISA works with industry leaders and public sector agencies to bring awareness to national critical infrastructure risk, as well as to educate and drive behavioral change towards the Nation's relationship with ICT and other critical systems, including 5G technologies.

- **Federal Departments and Agencies**: Through information sharing and coordination with federal departments and agencies, CISA helps establish

collective risk management strategies that support the development of national policy and strategy frameworks for future 5G deployment.

- **SLTT Government Agencies**: CISA engages with state, local, tribal, and territorial (SLTT) government agencies to understand common vulnerabilities and share assessments of potential risks posed by 5G technology. In addition, CISA works with SLTT stakeholders to discuss the specific policy, technological, and legal implications inhibiting secure 5G deployment.
- **Private Industry**: CISA relies on its partnership with the private sector to understand and manage risks posed to 5G technology. With the promise of connectivity between billions of Internet of Things (IoT) devices, it is critical that CISA and industry collaborate to identify vulnerabilities and ensure that cybersecurity is prioritized within the design and development of 5G technology. By coordinating with 5G network providers, infrastructure technicians, and telecom companies CISA is helping ensure that risk mitigation techniques are consistently applied across the network – both for existing 4G LTE and new 5G deployment. Through meaningful risk dialogues, industry working groups, and partnerships, CISA can provide extensive value to industry players looking to shore up their security apparatus.
- **Non-Governmental Organizations**: The research and development (R&D) initiatives carried out by associations, academia, and non-profits is invaluable to the security and resilience of 5G networks. From the analysis, design, testing, and development of new 5G capabilities, partnerships with these entities provide both subject matter insight and expertise that promote secure 5G deployment.
- **International Allies**: As 5G connectivity becomes a reality, there is the potential for an increase in untrusted vendors, equipment, and devices. Whether vulnerabilities are malicious or inadvertent, there will remain a need to maintain strong relationships with international partners to communicate risks and safeguard the flow of information.

Source: Transcribed from CIA US

(2) Cyber security in the EU

- Framework [3]

ENISA describes Cybersecurity framework of risks, mitigating measure and supporting as follows. For more detailed information on the chart, see https://www.enisa.europa.eu/.

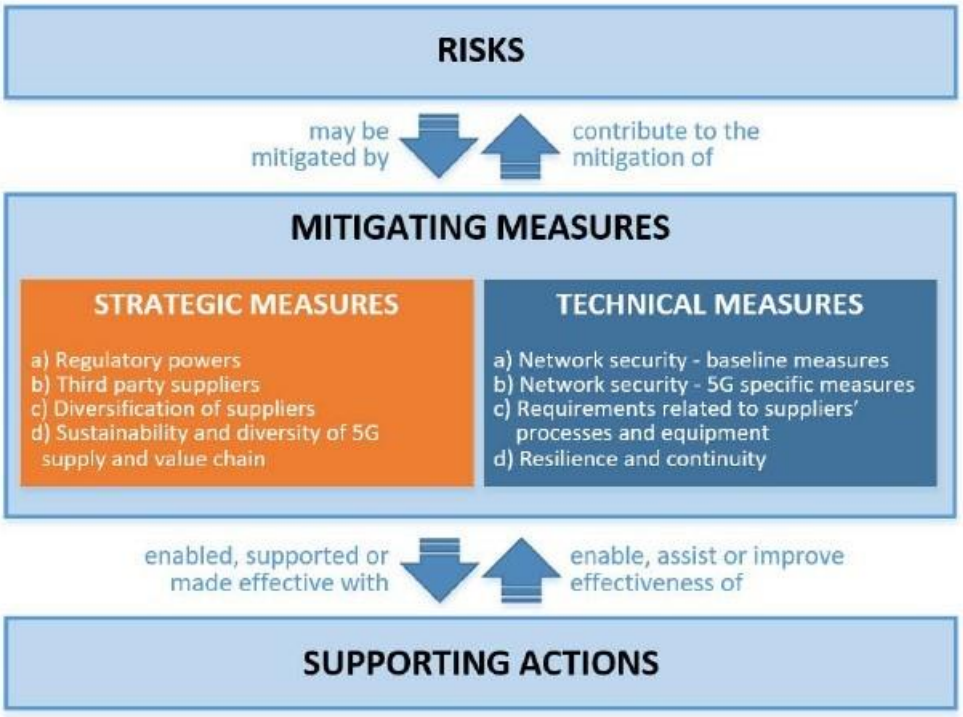


Figure 1. ENISA's Cybersecurity framework

I - Risk scenarios related to insufficient security measures	**R1-**Misconfiguration of networks **R2-**Lack of access controls
II - Risk scenarios related to 5G supply chain	**R3-**Low product quality **R4-**Dependency on any single supplier within individual networks or lack of diversity on nation-wide basis
III - Risk scenarios related to *modus operandi* of main threat actors	**R5-** State interference through 5G supply chain **R6-** Exploitation of 5G networks by organised crime or organised crime group targeting end-users
IV - Risk scenarios related to interdependencies between 5G networks and other critical systems	**R7-** Significant disruption of critical infrastructures or services **R8-**Massive failure of networks due to interruption of electricity supply or other support systems
V - Risk scenarios related to end user devices	**R9-**Exploitation of IoT (Internet of Things), handsets or smart devices

Figure 2. Risk scenario classified by ENISA

- Cyber security Capacity building in the EU

In addition, the EU is working on international collaboration for cyber security capacity building, mainly through EU Cyber Direct, and promoting its borderless nature. The

EU's commitment to the activities are as follows. For details, please refer to https://eucyberdirect.eu.

"The EU will step up work with international partners to strengthen the rules-based global order, promote international security and stability in cyberspace, and protect human rights and fundamental freedoms online. It will advance international norms and standards that reflect these EU core values, by working with its international partners in the United Nations and other relevant fora."

"The EU will further strengthen its EU Cyber Diplomacy Toolbox, and increase cyber capacity-building efforts to third countries by developing an EU External Cyber Capacity Building Agenda. Cyber dialogues with third countries, regional and international organizations as well as the multi-stakeholder community will be intensified. The EU will also form an EU Cyber Diplomacy Network around the world to promote its vision of cyberspace."

"The European Commission also aims at reinforcing the EU's industrial and technological capacities in cybersecurity, including through projects supported jointly by EU and national budgets. The EU has the unique opportunity to pool its assets to enhance its strategic autonomy and propel its leadership in cybersecurity across the digital supply chain (including data and cloud, next generation processor technologies, ultra-secure connectivity and 6G networks), in line with its values and priorities." [2]

- Data and privacy protection policy in EU

The General Data Protection Regulation (GDPR) is a regulation in the EU law on data protection and privacy within EU. It also addresses the transfer of personal data outside EU.

The GDPR was adopted on 14 April 2016, and was enforced from 25 May 2018. GDPR regulates strictly data and privacy protection, and penalty (up to 20M Euro) is defined.

At the same time, modernized and unified rules will allow businesses to make the most of the opportunities of the Digital Single Market (DSM) also benefiting from increased consumer trust.

Still, regulation alone cannot guarantee protection in the evolving big data processing landscape, if it is not properly implemented, monitored and enforced. This is where technology can play a crucial role by offering practical privacy protection tools and support the application of legal provisions.

To this end, EU focus especially on the concept of Privacy by design as fundamental principle of embedding data protection safeguards at the heart of new electronic products and services. In this context, we also study Privacy enhancing technologies (PETs) that can support privacy integration in systems and services.

Moreover, EU analyses and propose Security measures for the protection of personal data, following a risk-based approach. Particular emphasis has been given to Cryptographic protocols and tools and their possible implementation in real life applications.

(3) Cyber security in Japan

In Japan, the main agency in charge of cybersecurity is NISC. Please refer to the following website for more information.

NISC (National center of Incident readiness and Strategy for Cybersecurity) https://www.nisc.go.jp/eng/index.html.

NISC's comprehensive 5G security measures to strengthen 5G network security in Japan are as follows:

i. Establish method and system to verify vulnerabilities
   - Promote technical validation to identify software vulnerabilities in 5G networks; and conduct research and development of technical methods to find vulnerabilities in microchips
   - Impact analysis on 5G systems and users based on threat analysis using the results of the development of vulnerability verification techniques. Reflecting the impact analysis results into necessary security measures.
   - Formulate of a system to carry out the above verification and analysis activities in cooperation with 5G carriers, vendors, and research institutions

ii. Promote sharing of vulnerability information

- The “5G Security Steering Group” of ICT-ISAC Japan facilitates information sharing on 5G security between major 5G operators and newly entered local 5G operators

  (ICT-ISAC Japan: ICT-Information Sharing and Analysis Center Japan)

iii. Security measures

Regulation

- Requires operators to implement adequate cybersecurity measures, including measures against supply chain risks as a condition to obtain the approval of nationwide 5G deployment plans and the local 5G licenses; and
- Follow up the implementation of security measures by licensed operators;

Promotion

- Facilitate the deployment of secure and trustworthy 5G system by tax break system on operators’ 5G investments.

2.1.4. Enabling 5G development, trigger the Innovation and Technology Development:

(1) Innovation and Technology development

Governments can help by reducing bureaucratic barriers, improving access to capital, encouraging talent development and fostering a culture of innovation where risk-taking is not punished. Governments can also have an impact by becoming more involved in supporting local tech hubs, given their potential to facilitate the creation of new jobs and to develop solutions that tackle social challenges and positively engage young people. Promoting investment in local start-ups also helps broaden the available range of locally relevant content and services. This can help drive the uptake of the internet and digital services among the broader population. Multilateral and non-government organizations also have a role to play in the emerging tech innovation landscape, particularly in providing technical support and a platform for collaboration.

(2) Develop an open development environment

Market players in 5G development should continue to invest in new technologies, to innovate in the services they offer, and to compete to supply them to end users in new ways. In order to achieve this market environment, governments and regulators must work to remove regulatory barriers that are not necessary for these market processes.

Securing an open development environment is one of the solutions, and to achieve that, initiatives are needed for market players being able to actively implement Open RAN under the support of the government and regulators, breaking away from legacy development issues (such as vendor-lock-in). In other words, the fact that Vendor X's RAN equipment doesn't interface with Vendor Y's RAN equipment will eventually become a major impediment for development. Thus, securing interface between equipment will be very important in the future, and if not secured, it will be one of the main factors hindering the spread of 5G. Therefore, AMS should urgently work on the development of an open development environment based on their vision while deepening mutual understanding between the government and private sector.

As one example, Open RAN (Radio Access Network) technology is an attractive approach to building a communications infrastructure (not just 5G) using vendor-independent software and hardware. The technology uses, rather, RAN software and equipment using commercial off-the-shelf hardware (COTS) to create an "open" network where different vendors can cooperate in an interoperable system. This model allows mobile network operators to increase their flexibility while avoiding the risk of relying on a particular vendor.

The report, prepared by US-SEGA program, lists several advantages for mobile network operators to migrate from legacy models to the Open RAN concept.

i. The ability to use state-of-the-art hardware and software components from multiple vendors, rather than limited use of hardware and software from a particular vendor.
ii. Reduce investment costs by encouraging competition among multiple vendors in the hardware and software supply chain.
iii. Existing IT processes and procedures can open up network maintenance to more service providers to perform.
iv. Diversification of the vendors from which mobile operators can procure network equipment will enable fair competition, leading to lower network construction costs, stability of supply, and enhanced security. The diversification of the ecosystem shown here is very important, and governments and regulatory agencies need to implement various measures to promote this diversification.

v. Open RAN can be used to upgrade or expand existing networks, or to build new networks.

(3) *Develop an open innovation culture*

In recent years, technological innovations in communication infrastructure have entered an era in which we cannot talk about it leaving behind a communication network that utilizes IoT to create radical changes in social structure. The widespread development of 5G means development of basic infrastructure that supports the IoT era.

The connection between machines, and between machines and humans (the widespread of IoT) has become an indispensable element for the development of global supply chain which infrastructure is advancing in a leap-frog manner.

There are several stakeholders in the supply chain, and it is necessary to develop various technologies and ideas that are rich in diversity. For that purpose, rather than developing in a closed environment, it is also necessary to foster a culture in which related players (industry, academia and government) freely discuss and share their knowledge.

If the utilization of National 5G and Local 5G is regarded as one means for solving regional issues, matching communication technology, infrastructure, human resources, and financial resources will be a major issue. Technology and costs are evolving day by day, so in order to work on the realization of ideas and needs in the field, it is necessary to build a research system and another system capable to secure development funds, two systems in which industry, academia and government are united, not working separated each one on their own.

In addition, since 5G networks are not limited to a closed domestic environment, it is necessary to share information on technological trends and use cases with developed countries, so it is important to build a global development network (universities and research institutes including private companies) that takes diversity into consideration.

In the case of ASEAN, the establishment of a cooperative systems within ASEAN (ASEAN help ASEAN Program) is urgently needed, and the current discussed 5G Task Force would be one of them. It is also effective to build a virtual organization by research institutes in ASEAN that mainly research ICT and IoT technologies, and to build a place to exchange the latest information.

2.2. 5G Talent Development

While 5G mobile networks have grown, not everyone covered has adopted the digital solutions offered by connectivity. Closing this ‘usage gap” will require stakeholders to tackle issues in four key areas: affordability, usability and skills, relevance, and safety.

2.2.1. Digital Talents Skill category by 5G deployment stage

As more people connect, prioritizing digital skills in formal education and through government supported training programs becomes paramount. Successful digital skills development strategies focus on use cases that help people meet their life goals and needs. Such strategies should be based on a comprehensive framework that helps to map the digital skills required for these use cases, assess existing levels of proficiency, target specific areas of development and measure progress towards these efforts.

(1) Network and infrastructure (architecture level)

- Legacy networking for harmonization of existing technology
- While 5G network will be built up separately from existing network, we still need to connect with existing legacy infrastructure, including people using 3G/4G networked devices and cloud-based networking technology.
  - 5G technology is usually prepared and deployed with cloud server, especially edge computing services are key for low latency communications
  - 5G Core architecture and Network Slicing technology is required to build environment for 5G services
  - O-RAN and v-RAN technology can enhance deployment of 5G, in terms of easier addition/connection of network and cost efficiency
- 5G devices for commercial / private(local) deployment
  - Experts of terminal control devices, sensors which are component of 5G systems
  - Authorization of devices, testing, are important role of government authority
- Network security
  - Under 5G environment, increased routing points to be monitored to be secure
  - Massive number of IoT devices are connected at terminal, while those

devices could be manufactured without enough security, such as connected Smart TVs, door locks, speakers…, etc.

- Some of such devices are lacking encryption capability
- Coordinate with 5G security organizations in 5G developed countries, also co-work inside AMS (leverage existing organizations or set up a new one).

(2) Product Development

- With the deployment of 5G infrastructure, skill sets on how to develop new products and solutions that makes use of the features and benefits of 5G technology will be required.
  - These include programming and system integration skills to develop solutions that communicate with the 5G network and edge computing resources that are residing within the network.

(3) Device controlling and usage

For achieving 5G use cases deployed in society, talents who can understand and control 5G connected system. Three main areas are as follows:

- Big data, AI technology (machine learning)
- GPS, Smart device control
- Electrical Engineering for mass access devices and device development

(4) Talents in existing job roles such as Marketing, HR, etc. should acquire tech-lite skills for using solutions that will leverage 5G capabilities. Examples of such solutions are AR/VR/MR applications, Digital Twin, Virtual Immersive Interview Portal.

2.2.2. Talent development (key issues)

There are still large gaps in the development status and environment of IT human resources among some AMS. It'll take time to eliminate the said gaps, but it is important to work locally on the development of IT human resources under the philosophy of ASEAN help ASEAN Framework.

Below are some points to keep in mind when proceeding with talent development under these circumstances.

- Reskilling existing talents in AMS (Trainer, Operator, Student):
  Assessing current status, how many people are capable and be appointed to work by country in terms of focused area indicated at 4.3.1.

- Institutional resources (Official, Academic):

  Organize institutions inside states, connect with other countries top 5G institutions among AMS and outside ASEAN.
- Future requirements for each category above:

  Indicate future requirements to achieve 5G installation and socialization.
- Trainer resources in AMS, and outside ASEAN:

  Prepare hiring trainers if resources are not enough within the AMS.
- Evaluating talent development:

  5G deployment itself can be assessed by fact/plan comparison, while talent development could be the KPIs for procedure.
- Partner key industry players to train professionals for frontier 5G tech skills
- Build Community of Practice:

  Comprising of the academic institutions, training providers, government agencies and industry to discuss and coordinate 5G talent development efforts.
- Gender Gap:

  Many women are being left behind in today's increasingly connected world. Changes to school curriculums and training programs for women who lack digital skills have the potential to address this 'gender gap.' It may also be appropriate to address harassment via mobile phones and the mobile internet through awareness campaigns or legal and policy frameworks.

3. IMPLEMENTATION GUIDE FOR 5G DEPLOYMENT

3.1. Promoting trials, pre-commercial trials of 5G:

The transition to 5G technology will build on the achievements of 4G while also creating new opportunities for innovation. However, 4G networks will still play an important role in any digital transformation. A flexible policy framework is needed to ensure full realization of the benefits offered by 5G. Such foundations include a conducive regulatory environment that supports a forward-leaning policy framework as technology rapidly evolves and involves cross-sectors of digitalization; a fair and level-playing environment enabling healthy and robust growth; and a predictable and rationale investment climate to provide long-term certainty and sustainable investment.

(1) Development Image during the transition from 4G to 5G

When thinking of the transition of 5G, there are 2 new technologies that come to mind, NR and eLTE.

- NR: New wireless access technology (high frequency band)
- eLTE (enhanced LTE): LTE continuous evolution technology (low frequency band)

As shown in this figure, NR will not be suddenly implemented on a large scale from 2020. Although the time axis differs depending on the country, a rough development image is shown in the figure.

CY 2018: 4G LTE base station supports 4G LTE core network (Even in some AMS, urban areas have reached this level, but rural areas may still remain with 3G)

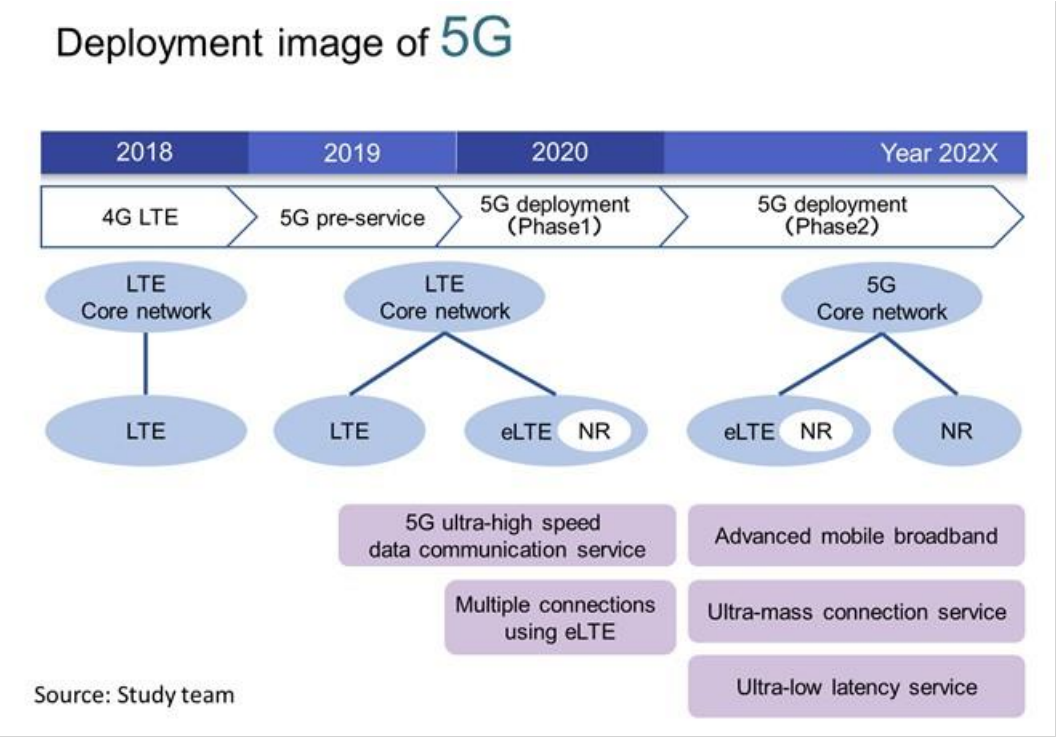
CY 2019-2020: 5G deployment (Phase 1) in a way that LTE and eLTE base stations correspond to the core network of 4G LTE. Once reaching this point, some of the high-speed, large-capacity and multi-connection characteristics of 5G can be achieved. However, eLTE is just an extended version of LTE, so there's no dramatic change.

After CY2020, 5G deployment (Phase 2) evolves and eLTE and NR correspond to the 5G core network, and finally displaying the 3 features of 5G.

It is not possible at this time to imagine when 5G deployment (phase 2) will be achieved in ASEAN, but it should also be noted that the things that can only be done with 5G are limited.

Even in the coexistence form of LTE and eLTE that is shown in the figure from 2019 to 2020, it is possible to develop DX in each ASEAN country.

The common 5G ecosystem deployment stages in AMS are depicted below:



(2) Strategic use of 5G-based Fixed Wireless Access (FWA)

Considering the current situation in ASEAN, it is necessary to solve the problem that 3G and 4G networks are not sufficiently developed in multiple AMS and the internal digital divide that exists in each country. It is difficult to formulate a 5G development scenario and sharing a time axis based on an ASEAN country where optical fiber backbone and 4G is already widespread. However, as described in ADM2025, there should be no time to lose in the implementation of 5G technology in ASEAN.

This section describes FWA, an effective and leapfrogging way to disseminate 5G technology in areas where optical fiber backbones are not laid yet.

Fixed wireless access, commonly referred to as FWA, is one of the most important use cases for early 5G network deployment. In many developed countries, several mobile operators and service providers are now using FWAs as an alternative to fixed wireless to provide last-mile connectivity at speeds of hundreds of megabits or gigabits in areas where fiber-optic networks are not well developed. U.S. research firms (Signals and Systems Telecom/SNS Research) estimated that 5G-based FWA contracts will account for $1 billion in service revenue by the end of 2019. Furthermore, the market is expected to grow at an annual rate of approximately 84% between 2019 and 2025, eventually becoming a $40+ billion market.

It is estimated that 5G-based FWAs can reduce the initial cost of establishing a last-mile connection by up to 40% compared to FTTP (Fiber-to-the-Premises). Furthermore, since 5G does not require cable installation like FTTP and can significantly shorten the deployment time, early field trials are required in several markets, and many vendors have developed 28 GHz band compatible equipment and applied it to the initial deployment of 5G-based FWAs. However, there are some issues such as the existence of radio dead zones inside homes and premises, and it is necessary to consider solutions such as the use of high-speed WiFi.

Until now, many ICT analysts believed that 5G-based FWAs are only suitable for densely populated urban areas. However, many rural operators, including C Spi ICTU.S. Cellular in the U.S., are beginning to see 5G as a way to provide last-mile broadband connectivity to underserved rural communities.

Here's one solution to bridging the digital divide in ASEAN.

(3) Potential Challenge and Capabilities of Local 5G

In the world after COVID19, the globalization of multinational corporations will promote the diversification of supply chains across different economic zones, and the spread of safer and lower cost 5G networks will be urgently needed. The speed of this change is incomparably faster than the speed of economic development in the past, and in order for ASEAN's communication infrastructure development to catch up with this change, it is essential to consider the introduction of LOCAL 5G that applies to Open RAN in parallel with the spread of optical backbone networks.

When considering the introduction of LOCAL 5G to SEZ (the Special Economic Zone), Industrial Parks and Universities as a pilot in AM countries, the following preparations are required.

- Matching the needs of the target area with the characteristics of LOCAL 5G

Whether the purpose of introducing Local 5G is to foster local industries, disaster prevention, mitigation, promotion or revitalization of primary industries, development of high-speed broadband and so on, it is necessary for relevant parties to thoroughly consider and identify stakeholders. Once identified, the operating entity (license holder) of LOCAL 5G would be determined.

- Preparation of equipment, wireless technicians, and operation management

In the case of ASEAN, when introducing Local 5G, it is necessary to prepare (1) core network, (2) base station, (3) terminal, (4) edge computing (MEC) equipment, (5) optical fiber backbone, and (6) wireless engineer. The operating entity will either procure these items on their own, including engineers, use the equipment and human resources provided by mobile phone carriers and vendors, or maintain only some facilities such as base stations on their own. There are three main options, such as renting the rest of the equipment. Similar options exist for operations management.

In any case, it is necessary to try using Local 5G first, starting by conducting it as a pilot. Since there is already an ASEAN country implementing a pilot project on Local 5G, sharing the case study from the perspective of project management would be an effective sharing of information, especially for AMS where Local 5G implementation is delayed.

Table 2 shows the Potential Challenge and Capabilities when introducing LOCAL 5G.

There are the possible technical issues of LOCAL 5G and the ways to address them. LOCAL 5G has a wider communication area than Wi-Fi, and it is easy to ensure communication quality and security, although some issues still remain. It is expected to be used as a network of mission-critical control systems that deal with risks such as interference.

In manufacturing logistics and medical sites where high reliability and stability are required in the control of industrial robots, there are some technical problems in applying LOCAL 5G. There is a high possibility that the deployment spread and speed will accelerate by responding to these issues.

In AMS, where it seems that it will take time to develop the core network, if trying to apply 5G first, the construction of Local 5G would be effective in that case.

Table 2. Potential Challenge and Capabilities of Local 5G Application

	Challenges	Capabilities
Low delay guarantee	• Need for shifting from the best-effort type of communication quality assurance, which is common in LTE services provided by carriers, to guarantee type assurance • Avoidance of network delays that cause malfunctions of industrial robots or other trouble	• Mechanisms such as priority frame transmission and bandwidth reservation that affect the operation of industrial robots. • MEC※2, which places a server in the vicinity of a base station and returns low-delay processing such as robot control.
Stable Operation guarantee	• The millimeter-wave frequency band to be allocated to 5G has a strong rectilinear and cannot obtain a diffraction effect, so there is a radio wave shadow that can cut of radio connection. • Stable operation when an autonomous robot such as an automated guided vehicle (AGV※1) enters a radio wave shadow zone or crosses a coverage area of a base station	• Arrangement of base stations and relay antennas that overlap the coverage area of base stations and redundancy of networks. • Beamforming for autonomous robot tracking and base station handover.
Interoperability guarantee	• Interoperability for a gradual transition to local 5G from existing wired infrastructure such as optical fiber and industrial Ethernet.	• Integration of protocols including the conversion of wired Ethernet frames, such as industrial Ethernet, which is expected to be standardized in the manufacturing field, and its extension, TSN※3, to wireless 5G frames.

Source: Study Team ※1 AGV：Automatic Guided Vehicle ※2 MEC：Mobile Edge Computing ※3 TSN：Time Sensitive Network

3.2. Phased approach:

It is difficult to come up with a standard model for a phase approach in the ASEAN region under the circumstances where the ICT infrastructure development status, development stage, and investment priorities in each ASEAN country is different.

In this section, we will present an image of the phased approach.

(1) The first 5G deployment has been usually centered in cities and focused on delivering an enhanced broadband service to consumers. Higher throughputs, bundling of new devices, and new content services provide attractive consumer propositions.

(2) After the initial 5G rollout, the next deployments will extend the reach of 5G as operators start to cover major transit routes (highways and rail tracks) to enable the first generation of (semi-) autonomous vehicles (such as autonomous trucks). Depending on spectrum availability, mmWave densification in inner cities and hot spots (shopping centers, train stations, and sports arenas, for example) may come to fruition. Additionally, high-bandwidth networks may start to penetrate rural towns, although it is unlikely that the rural rollout will be completed during these phases.

(3) The deployments of micro-edge computing centers, as well as rural deployments and mmWave densification will be completed. In addition, street-by-street coverage will expand to second tier transit routes— regional roads, in particular.

The details of Phase approach are described in detail in *5. Conclusion*.

3.3. Issues in deploying National 5G and Local 5G

AMS should carefully consider reasonable and appropriate universal service obligations by 5G. Population coverage obligations should be attached to low band spectrum only. There may need to be a consideration beyond traditional population coverage, to incorporate backbone routes. Obligations should be predicated on use cases, with industry consultation on the matter.

If the utilization of National 5G and Local 5G is regarded as one means for solving regional issues, matching communication technology, infrastructure, human resources, and financial resources will be a major issue. Technology and costs are evolving day by day, so in order to work on the realization of ideas and needs in the field, it is necessary to build a research system and another system capable to secure development funds, two systems in which industry, academia and government are united, not working separated each one on their own.

To efficiently implement 5G policies, it is important to avoid stove-piping in policymaking by coordinating the efforts of each ministry and agency, and for the government as a whole to have a bird's eye view of the current situation in their country and formulate optimal 5G policies. In addition, collaboration between the public and private sectors will provide an opportunity to create new and innovative use cases.

Considering 2025, four years from now, it is not difficult to imagine that there'll still be several areas in AMS where the spread of national 5G networks is delayed. Waiting for the infrastructure to be put in place takes away the opportunity to benefit from 5G services, and the private sector runs the risk of losing business opportunities.

In such cases, at the same time as National 5G is spreading, it is expected to have Local 5G implemented into limited areas (buildings, premises, factories, special economic zones, etc.) under the cooperation between the public and private sectors.

4. 5G USE CASES

5G technology is considered essential to the creation of a favorable platform to help promote innovation and development in many different industries, such as entertainment, transportation, manufacturing, healthcare, and education, energy, agriculture, smart city, etc. Therefore, both regulators and carriers are very interested in identifying potential applications along with business models on 5G network infrastructure and services for the early and long-term stages of the 5G development pathand set up a roadmap for 5G network development accordingly.

The applications of 5G technology are based on three main use cases which will be reviewed before going to discussion of applications in a number of industries.

- *Enhanced Mobile Broadband (eMBB)*

eMBB is the most well-known use case of 5G which provides enhanced mobile broadband services. eMBB enables more users to gain benefits from high-bandwidth applications, such as 4K video, virtual reality, or other multimedia applications in which average speeds 10x faster than the previous 4G generation. Furthermore, a significantly lower target latency will allow users to make the most of advanced cloud computing applications, where software is run on a server and accessed by users via the Internet.

- *Massive machine-type communications (mMTC)*

Massive machine-type communications (mMTC) which provides connections to very large numbers of devices that intermittently transmit small amounts of traffic is the backbone of the next generation of Internet of Things (IoT). In comparison with the current technology used in IoT devices (WiFi or 3G/4G) which are generally inefficient for the type of long-term, low-power, and low-throughput communications, 5G mMTC will be possible to meet these needs and more. mMTC technologies' characteristics are expected to provide low power consumption that enables devices to operate for many years, low cost device, improved outdoor and indoor coverage compared with existing wide area technologies, secure connectivity and strong authentication, optimised data transfer for small, intermittent blocks of data, simplified network topology and and its deployment.

With a wide range of advantages, 5G mMTC has the potential to be a paradigm-shifting technology that will reform how users interact with technology and boost productivity and help spur economic growth also.

- *Ultra-reliable low latency communications (URLLC)*

Ultra-reliable low-latency communication, or URLLC, is one of several different types of use cases supported by the 5G New Radio (NR) standard, as stipulated by 3GPP (3rd Generation Partnership Project) Release 15. URLLC will cater to multiple advanced services for latency-sensitive connected devices, such as factory automation, autonomous driving, the industrial internet and smart grid or robotic surgeries.

The below part presents some potential application scenarios of 5G that have been deploying in a number of countries inside and outside the ASEAN region.

(1) Healthcare, remote medicine

In the medical field, many surgeries can be performed completely remotely by doctor-controlled surgical robots with the support of 5G technology. The operation of the robot requires absolute precision to every millimeter and takes place immediately according to the doctor's operation through the remote-control system. Accompanied by the image transmitted directly between the two sides must be clear and stable in real time. This requires a signal transmission system with almost zero latency and fast, strong and stable signal transmission. That is one of the applications of 5G networks that to be expected in near future. Below slide is another application scenario of 5G in the medical field to be deployed in Thailand. [1]

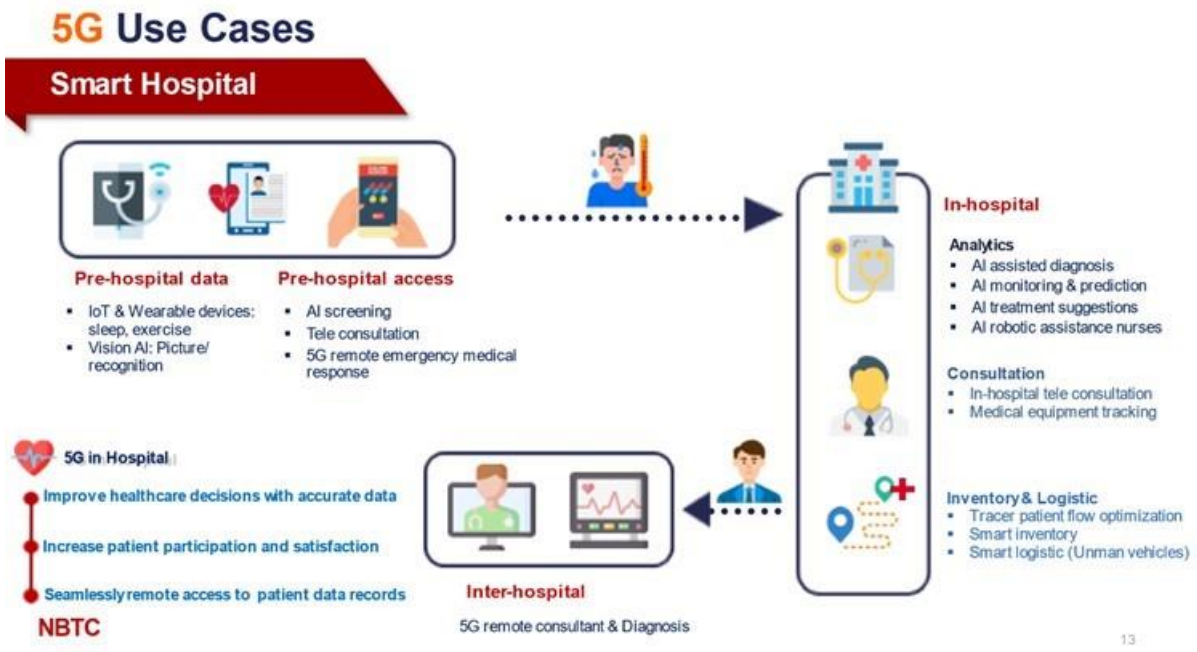


Figure 3. Smart hospital use case in Thailand [1]

(2) Agriculture

Agriculture sector has been transforming rapidly by the advances in blockchain, big data, and massive IoT technology in current economies. 5G networks were tested and proved to provide exponentially faster download and upload speeds, as well as stable, real-time communications between devices over wireless networks.

A collaborative project in the Netherlands which aims to define the impact of 5G on farming tools and methods, particularly fighting the growth and spread of pest-carrying leafy plants in between potato plants is the Kompas experimental farm. The drones examine the field and hand-off visual information records to the 5G Field lab. There, the information is quickly changed over into exact guides and afterward organization of a self-pushed sprayer to scatter the specific measure of substance specialist needed for each spot.

In Thailand, 5G technology can be applied to collect and analyze data of sensors in agriculture, and serve to monitor and predict the condition of crops. Thereby contributing to increase production, reduce costs and resource, and improve overall farm efficiencies [1] .

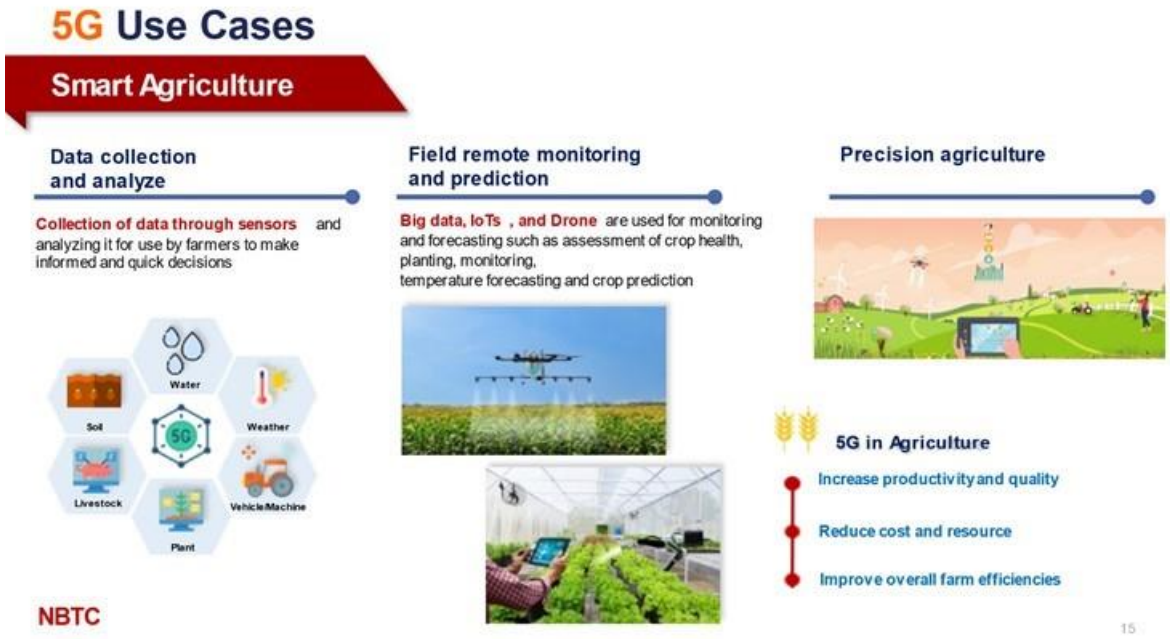


Figure 4. Smart agriculture in Thailand [1]

(3) Energy Management

Much of the world's energy is used by buildings, and designs that incorporate 5G sensors can significantly reduce energy use. Lighting, heating, cooling and other operations are distributed according to need, with energy generated by the building itself, for example through a solar system. In the office environment, 5G can be combined with big data and AI (Artificial Intelligence) to create models from workers' footsteps to determine when lighting, heating or air conditioning should be adjusted. Resource-intensive buildings like hospitals can also use 5G and AI sensors to help perform critical maintenance based on previous patterns. This is also useful in a large university or corporate campus where there are many multi-purpose buildings.

Connected things of things (IoT) devices such as in smart cars, homes, buildings and stadiums will quickly alert the grid in use to make adjustments and respond in a timely manner and flexibility. Decommissioning IoT devices when not in use will significantly reduce energy requirements. In fact, a recent report by O2 network carrier argues that this could lead to a 12% reduction in household energy use, equivalently 6.4 million tons of CO2. The use of renewable energy sources such as wind and solar is increasing but subject to disruption. Therefore, 5G technology will allow better management of these resources to balance energy generation and consumption.

In the field of power distribution grids, the cost of faults is driving the increased need for power grid protection. Connectivity, sensors and automation can allow greater availability and protection of the power grid. Distribution system operators can better anticipate, avoid, control and automate power grid protection through the support of ICT and wireless connectivity technology. The current distribution system operators use a variety of wireless connectivity technologies such as private radio technology in the frequency band VHF/UHF, Wi-Fi and 3G/4G cellular networks. The cost-effectiveness and preference for a specific technology will ultimately depend on the type of power grid and regulation, as well as the customer situation and density. However, for some certain use cases which require high protection from faults such as line differential protection, very fast connectivity with ultra-low latency such as 5G will be needed to achieve the performance requirements.

(4) Education

Augmented Reality (AR) and Virtual Reality (VR) innovations have been in improvement for quite a long time, yet AR/VR systems stay obliged by various specialized restrictions. Beside short battery lives, overheating, and deficient figuring capacities, two obstructions including transfer speed prerequisites and responsiveness still are the fundamental challenges. AR/VR streaming will require not just expanded transfer speed for both downlink and uplink information streams yet, in addition no less than 20 Mbps. The existing networks assign fundamentally more range to downlink information conveyance, which affect the buyer's experience.

When 5G is applied, it is expected to help AR/VR-based solutions which are relied upon 4G networks now but 4G will reach the Gbps limitation soon, enabling immersive training experiences in the field of education. Besides, testing AR/VR systems are already being used to provide a more cost-effective, versatile, and compact alternative to traditional pilot test programs for pilot preparation. Mechanical actuators simulate object solidity, coarse surfaces, and, unexpectedly, the sensation of handling real objects to help learners develop muscle memory.

A pilot project was recently launched in Dubai to help develop a 5G-enabled cloud VR delivery system that allows for continuous cloud delivery of intelligent AR/VR media content.

(5) Transportation / Automotive

For any self-respecting Smart City, smarter roads and automobiles are a must. Users' expectations and requirements must be able to adjust and evolve a smart public transportation system. This includes installing cameras, sensors, and other technology in public infrastructure, such as traffic signals, stop signs, and speed bumps, to enable the gathering of data. Vehicles play an important part as well. They must be able to navigate the city as efficiently, safely, and reliably as feasible, whether they are autonomous or not.

Instrumentation systems in autonomous vehicles are expected to need to transfer 4,000 GB of data per day, the equivalent of 3000 4G users today. Not only stopping at the need for huge data transmission, self-driving cars also require a signal delay time of ms to execute control commands, ensuring absolute safety for participants traffic. In the case of self-driving cars running at a speed of 100 km/h, when detecting an obstacle ahead, the car needs to order the braking mechanism to brake to ensure the safety of road users. The request time is no more than 01 ms after receiving the command from the sensor. This requirement demonstrates the importance of ms-delay communication in the application scenario in autonomous vehicles. Means of transport will be also able to connect and communicate with each other, and at the same time can communicate with traffic infrastructure (such as signal lights, warning areas...) accidents, increase safety for traffic users.

In Korea, the Korea Transportation Safety Authority (KOTSA) has collaborated with several private firms to establish the “K-City” test site in South Korea. The pilot city has successfully served as a platform for public- and private-sector organizations to test their 5G-enabled self-driving technology. The experimental 5G network in place uses 28 GHz ultra-high frequency broadband and includes a 20 Gbps download capacity, a 5G communications control center, and a 5G 3D-HD map with a high precision of fewer than 20 centimeters. It is backed up by mobile network infrastructure, such as mobile edge computing sites near base stations located across the test city.

(6) Smart factory (controlling IoT sensors, surveillance…), Robotics

Low-latency communication and ultra-high reliability are also prerequisites for building smart factory models, contributing to the success of the 4th industrial revolution

(Industry 4.0/4IR) of humanity. Through devices, machines, and even machine parts capable of radio connectivity and programming, a radio network in the factory is formed and allows for automatic monitoring, monitoring, and control of the entire process and production cycle. In these factories, not only people but also equipment and machines are connected to each other via networks.

A Smart Factory is not only able to cope with the challenges encountered in the past and present, but also can respond flexibly to situations that may arise in the future. Some technology firms in Japan such as NEC are promoting the transformation of manufacturing plants to form smart factories in which IoT, AI or 5G local technology solutions are the core platform. [7]

- Test automation with high-definition images and video [7] :

Previously, images were used for testing, but narrow network bandwidth and other problems limited the ability to transmit large-capacity high-resolution video for post-analysis processing. However, 5G will help with real-time processing of actions based on the alignment between the camera and the robot, namely the recording of defects in products running on the production line with a high-resolution camera

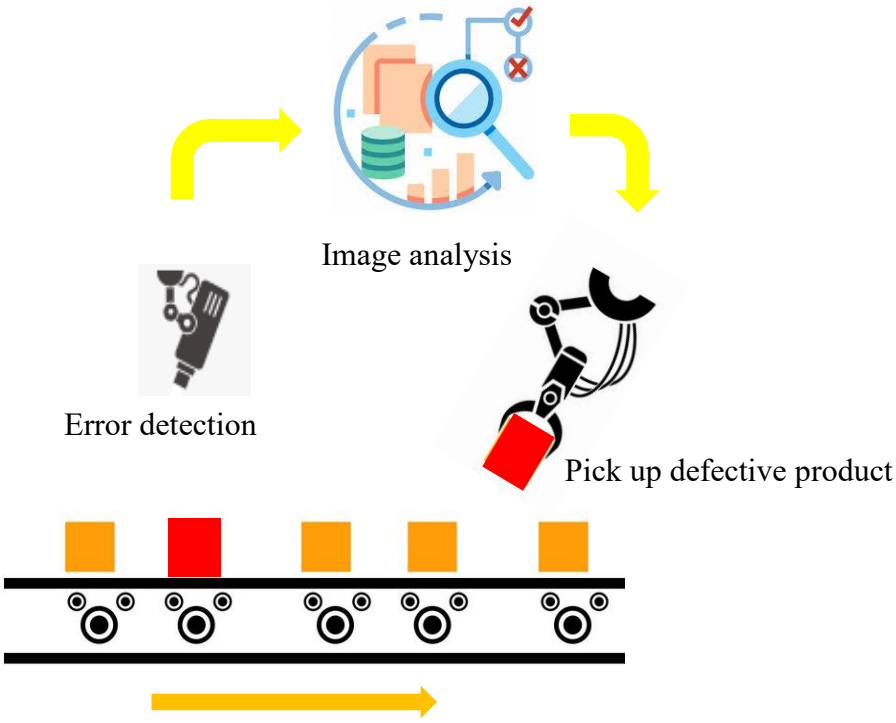


Figure 5. Usage scenario: Inspection process [7]

- Supporting workers using augmented reality (AR) [7]

One of the problems that the factory needs to solve is the shortage of skilled technical experts because they retired or they changed jobs but have not passed on all their experience to the next generation. On-site engineers have little experience so sometimes they will take a long time to fix problems, and thus affect the production schedule. For these cases, one of the solutions is to ask a technical expert for remote assistance using AR glasses. Thanks to the high-resolution 4K camera, the entire scene of the incident will be reliably transmitted in real time over the 5G network to a technical expert equipped with AR glasses.

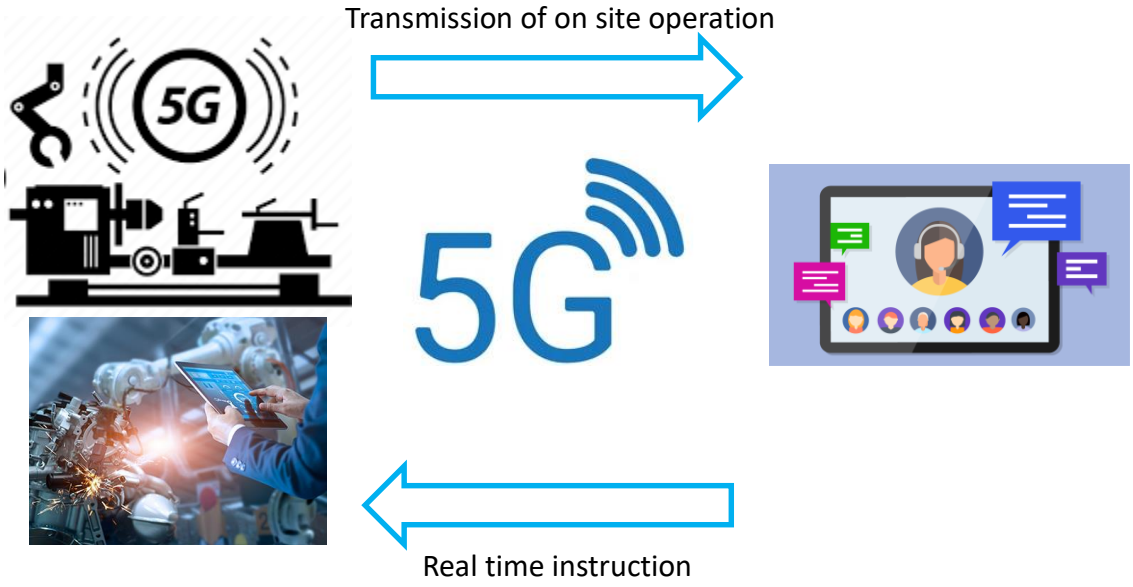


Figure 6. Usage scenario: Production equipment maintenance [7]

- Advancement of automatic guided vehicle (AGV) through Coordinated Control [7] **:**
One of the disadvantages of automated transport equipment which are introduced for unmanned material transportation in factories and logistics warehouses is lack of flexibility when there is any changes in production line layout. This issue may be solved by adopting the trackless automatic guided vehicle (AGV) that features the capability to change the transport path in response to changes in the surrounding conditions (Figure 7).

In order to avoid traffic congestion when several AGVs run simultaneously, Multi-Robot Controller (MRC) by features of 5G, the ultralow latency and the simultaneous multi-connections has been introduced. MRC can serve as the centralized AGV control

system to collect real-time information on the running conditions of AGVs and give real-time instructions of the optimum path to be taken for each AGV.

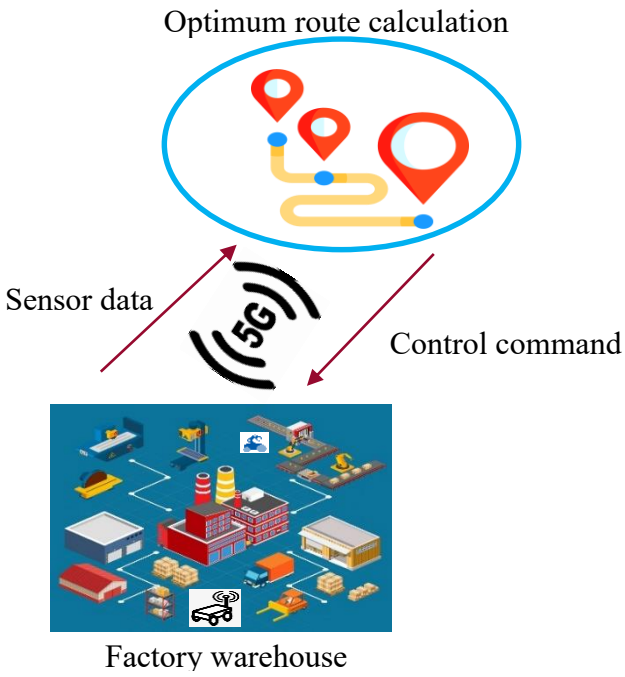


Figure 7. Usage scenario: Factory goods warehouse

(7) Finance-Banking

Greater bandwidth allows banks to create a much better experience even if they don't need to modify digital banking products. With 5G, banks can bring service experiences to users over the internet without requiring them to download apps to smart phones. 5G will allow mobile apps to keep less data on the device. And since cloud-to-device data transfers are virtually free in a 5G environment, we can create lighter, more responsive apps. The application is more compact, using cloud also means less users have to update the application. Banks will have to worry less about application versions, confident that the customer experience will be more consistent, and when security updates are needed, they will be instantly applied across the system. Bank branches and ATMs upgrading the network within the branch to 5G will help banks.

In addition, 5G could allow video exchange between a bank branch and headquarters or even the use of virtual reality. Remote experts can help customers better understand the complexities of the bank's products and services. Banks can also take advantage of 5G for mobile branches. During festivals, in places of large gatherings, banks can quickly set up new transaction points with ATMs and service counters set up. The high speed

and responsiveness of 5G can provide facial recognition (a service that needs quick access to a cloud database in real time), which service counters use.

5G can also be used for remote support and training. For example, a bank still uses an old ATM or POS device that few people know how to fix. With 5G, branch staff can get remote help from experts. Through the augmented reality glasses worn by field staff, the experts at the center can see detailed information and guide field personnel step-by-step.

(8) Virtual and Augmented Reality

South Korea is one of the most advanced 5G markets and among the first places to launch 5G AR/VR. In April 2019, 50% of the population of South Korea had access to a 5G network built by one of the three national operators, and early versions of 5G VR/AR were already available. By June 2019, there were more than 1 million 5G users – faster than initial uptake of 4G. Meanwhile, the first cloud VR/AR solution using 5G (LG U+) went online. One third of 5G users were VR/AR, a very high adoption rate. 5G AR/VR business models have developed fast, inspired by mobile video models (traffic management, prime service content and exclusive headsets). [*Sources: Huawei press release, LG U+, SKT, KT]*

In the field of sports, virtual on-site travel, with high-speed, stable and super-low latency connection, users can also experience real-time the places they want to visit, without leaving the house. explorer, or watch live football matches online like sitting at the stadium. Or playing real-time sports games such as table tennis, tennis... 5G will make players feel like they are playing in reality, not playing through cyberspace.

5. CONCLUSION AND THE WAY FORWARDS

A holistic policy framework that reflects the changing digital landscape while reducing costs and barriers to network deployment will deliver the best outcomes for society and the economy. If regulatory policies and institutions fail to adapt, markets can become distorted in ways that harm competition, slow innovation and, ultimately, deprive consumers of the benefits of technological progress. Efforts to encourage network investment, modernize regulation, promote the digital economy, and demonstrate digital leadership can help to set the proper foundation and facilitate the deployment of 5G.

In order to successfully deploy 5G and put it into commercialization soon, it is very important for AMS to quickly issue the national plans and strategies in particular 5G frequency allocation for carriers. The completion and early issuance of 5G-related management documents will be an important factor in accelerating the process of 5G network formation and development in ASEAN, especially standards related to the management of 5G equipment and services.

It is not difficult to foresee that the spread of 5G technology will create more demand for electricity in the next decade in the less developed ASEAN countries, which have been facing challenges in their electricity situation during the 21st century. The spread of the 5G ecosystem will create more demand for electricity, possibly causing electricity shortages. In light of this situation, countries concerned should consider formulating power supply plans. In this regard, based on the basic principle of "ASEAN help ASEAN", it is necessary to actively promote usecases and sharing of solutions.

A new policy and regulation of "Sandbox" approach could be explored as an option, where regulations can be tested in different regulatory contexts to help a rapid roll-out across the wider region. This is one of the approaches suitable for Industry 4.0 and suitable for embracing new business model and innovations. This is an approach to identify issues including regional characteristics, such as hitting sandboxes with various usecases through small-scale pilot projects and demonstration experiments, and to consider local regulatory contexts. It is important to refer to developed countries' cases, but when applying the Sandbox approach, it is desirable to share the knowledge among AMS.

Regarding infrastructure sharing, the AMS governments' needs to have policies to support businesses providing 5G services as well as promote stakeholders to apply the new technologies, especially 5G technology with potential applications contributing to the economic and social development. It is also recommended to: (i) form legal regulations for the sharing of telecommunications infrastructure between enterprises to ensure efficient use and cost savings when deploying 5G; and (ii) modernize regulations and policies in the direction of supporting mobile operators to develop favorable base station/broadcast infrastructure.

The telecommunications businesses in each ASEAN country need to cooperate in building modern telecommunications infrastructure, using common telecommunications infrastructure, increasing network capacity and saving the investment in 5G networks. Telecommunications businesses coordinate to deploy practical applications in densely populated cities such as: Smart transportation, Smart grid, Smart lighting, Smart waste control, etc.

On the basis of the research on current status of AMS and international trend of promoting 5G development, some recommendations for 5G deployment in ASEAN are as follows:

5.1. A proposed roadmap for implementing 5G in ASEAN

Subject to AMS' different level of development and available resources, the proposed 5G technology deployment roadmap for ASEAN is to be organized in 3 phases.

- Phase 1: This is a preparatory phase with a focus on upgrading and completing the current 4G network infrastructure and services, gradually preparing the necessary infrastructure for deploying 5G technology in the next phase.

  In considering 5G development, it is necessary to actively work on getting rid of the legacy type components (i.e. avoiding vendor lock in) that might have been an obstacle to the development. In this sense, the introduction of O-RAN is an urgently needed initiative.

  In existing mobile networks, devices from a specific vendor are installed, resulting in "vendor lock-in" that makes it difficult to change the vendor of the device.

  By promoting O-RAN, network operators will be able to configure their networks with terminals from multiple vendors, which will promote competition among vendors and lead to lower network prices. As a result, competition among vendors will be promoted, leading to lower network construction costs, stability of supply, and security.

- Phase 2: This is a short but pivotal phase with a focus on deploying and completing narrow-scale testing of both 5G pre-commercial technology and services. Thereby, accumulating experience, choosing the optimal solution for the next stage of implementation
- Phase 3: This is the stage of commercializing 5G network with step by step providing services to meet the immediate use needs of each area as well as specific customer segments. Depending on the conditions, when appropriate, we will proceed to expand the service area to fully provide all 5G application scenarios for all user segments.

  It seems that there are some AMSs that cannot catch-up on the above-mentioned deployment roadmap, but it is necessary to flexibly change the time schedule according to the infrastructure development status of the country concerned. In some countries, for example, Phase 1 may continue until 2025.

  At that time, it is very important to share the knowledge among AMS and the cases of problem solving that preceded the development of the 5G ecosystem.

5.2. 5G infrastructure development and sharing in ASEAN

a. Government agencies/authorities

- Having regulations on permitting the sharing of passive telecommunications technical infrastructure;
- Having regulations on permitting the use of public fund for telecommunications infrastructure development;
- Having regulations on permitting the installation of telecommunications works at offices and state agencies; and
- Build an environment where free competition is guaranteed.

b. Telecommunications companies

- Deployment of sharing and common use of infrastructure;
- Exchange and agree on a number of designs of antenna masts to ensure the requirements of construction safety, urban beauty and enhance general usability;

- Optimizing the load and capacity of the antenna masts and telecommunication stations built so that they can be shared and used in common;
- Decorating, compacting, and undergrounding telecommunications cables to enhance aesthetics, safety and optimize cable capacity and load so that they can be shared and used together with the cable sewer system, cable poles; and
- Promote the development of system that allow for free competition.

5.3. 5G services quality management in ASEAN

General principles

- Ensuring the benefits of using the services;
- Ensuring the benefits and development of the business; and
- Ensuring the sustainable development of the telecommunications service market.

Orientation for 5G services quality management

- Considering the level of 5G network deployment and its services development; and
- Considering the supply and demand on 5G services in ASEAN.

5G services that need quality management

- Fixed broadband internet access (2020-2021);
- Local 5G (2020-2022);
- Enhanced Mobile Broadband (2021-2022);
- M2M/IoT applications (from 2022-2023); and
- Ultra-low latency IoT communication applications (from 2024-2025).

5.4. Proposed cooperative activities in ASEAN

AMS should:

- Work on a common approach to tackle the barriers currently hindering the rollout of 5G networks.
- Work to reduce the cost of 5G deployment, remove unnecessary administrative barriers, and support cross-border services.

Regarding the above two points, it is necessary to consider measures for cross-country issues in case an incident occurs in the cross-border services within ASEAN.

It is important to discuss different matters related to various services provided across national borders in advance among AMS and have a common understanding based on the concept that ASEAN matters will be resolved within the ASEAN region.

- Work to avoid or minimize any delay in the granting of access to the spectrum to ensure timely 5G rollout.
- Work to put the most suitable methods in spectrum auctions and commercial licensing;
- Promote cooperation among member states to accelerate the rollout of 5G and loosen regulations related to 5G deployment, including cutting rigid regulations, improving spectrum access and border frequency coordination between countries.
- Publish a guide to 5G strategy and road map deployment for member states and enhance the cooperation to create the favorable business environment for the deployment of 5G.
- Build a system to analyze the supply and demand of human resources in the field of 5G as well as related industries as a workforce with the right skills, techniques, and qualifications will enable countries to build networks and develop new 5G applications.
- Enhance the preparation of a solid foundation as well as a rich ecosystem determines the success of 5G before, during, and after deployment. ASEAN member states should proactively build the foundation early, the 5G ecosystem to greatly reduce obstacles and accelerate the commercialization of 5G later.

In short:

- For 5G ecosystem development in ASEAN, the government's role is particularly important in supporting the private sectors to deploy network infrastructure as 5G networks require a high level of investment before services and applications in commercialization. The government also plays as enabling driver of the 5G

deployment process and the protection of fair competition while ensuring technology neutrality.

- The current complicated pandemic situation has also accelerated the adoption of 5G technology in many areas, especially health care, education and training. Along with other emerging technologies, 5G has the potential to change the way we live and work even in ways we haven't fully envisioned. 5G is considered by the world as one of the important solutions contributing to the socio-economic recovery after the COVID pandemic.
- Especially during the outbreak of the Covid-19 pandemic, many businesses have had to accept digital transformation to support or enforce the remote work policies and regulations. The regional workforce is now heavily reliant on digital services and new collaboration tools, which have had a major impact on the ASEAN telecommunications infrastructure. Telecom companies have been working hard to build new infrastructure to meet this demand of which 5G deployment is an integral part.

ANNEX 1: STATUS OF 5G IMPLEMENTATION IN ASEAN AND ITS DIALOGUE PARTNERS

1. Status of 5G preparation and implementation in ASEAN

The ADM 2025 contains the 4 visions shown below in Table 3. In order for AMS to aim for these visions, the promotion of 5G development would play an essential role in ICT infrastructure development.

This section shows the current status of AMS as of 2021.

Table 3. Vision of ADM2025

First it means a society in which everyone in ASEAN is using digital services to enhance their daily lives – to interact with friends and family they cannot meet; to entertain themselves; to buy and sell things; to manage their money; to make better decisions; and in many cases to receive a better education and better healthcare through digital services. Secondly it means ASEAN Member States (AMS) economies in which businesses large and small use digital services to make themselves more productive; to interact more quickly and cost effectively with partners in their value chains, and to use new ways to sell to consumers. It also means public bodies which offer a much wider range of easy-to-access and quick-to-use services to ASEAN citizens. Thirdly it means a more prosperous ASEAN region as digital services make trade with other AMS fast and frictionless. This in turn allows the most innovative and efficient businesses in each ASEAN country to expand more easily across the ASEAN region so as to offer a wider range of cheaper and better products to all ASEAN consumers. Finally, it means an ASEAN economy which is able to recover more quickly from the COVID-19 pandemic over the next few years (in line with the ASEAN Comprehensive Recovery Framework) and to do so in a way which is greener and more sustainable in the long-term. Source: ADM2025

1.1. General assessment

Almost all AMS are of the view that 5G allows to meet traffic and connectivity demand, contribute to the national digitalization transformation, solve the social problem such as transportation, logistics, environment, education, medical, healthcare, manufacturing, natural disasters, anti-terrorism, crime. Thailand also has a view that 5G network will support applications for various vertical sectors such agricultural, energy, media and entertainment which will contribute to Thailand's GDP growth. Malaysia's view is that 5G is an economic imperative that holistically influences the quality of life, businesses including small and medium-sized enterprises, as well as the government. In Malaysia, development of solutions are focused in nine key verticals i.e.: Agriculture, Digital Healthcare, Education, Entertainment/Media, Manufacturing & Processing, Oil & Gas, Smart City, Smart Transportation, Tourism. These verticals are seen directly correlated to the country's economic growth.

Some AMS recognized that building and issuing policy framework or action plan on 5G deployment is extremely important, in the meanwhile some AMS are of the view that this issue is very important and one AMS acknowledge that it is important.

1.2. Analysis countries by countries

1.2.1. Brunei

Brunei is ready for 5G with the establishment of a 5G Working Group (Spectral and Policy Group, Infrastructure and Application Group, Awareness Training Group), deployment of multiple 5G stations, and band announcement frequency 700 MHz and 3.5 GHz for 5G testing. Brunei has developed a pilot "sandbox" policy framework to promote the development and testing of 5G technologies and applications.

The 5G task group consists of representatives from government agencies, vendors, Tel Cos, academia and private sectors which further divided into 3 subgroups looking into:

(1). Policy, Regulatory and Spectrum

(2). Uses cases, Application Development and Infrastructure

(3). Education and Awareness

The taskforce will be responsible to provide a final report which contains proposals and recommendations in facilitating 5G implementation in Brunei Darussalam in twelve (12) months after its establishment.

1.2.2. Cambodia

Cambodia Government is focusing on three major issues on 5G including the national strategy, establishment of 5G task group and policy making. Cambodia is also planning 5G roadmap and policy for infrastructure sharing.

1.2.3. Indonesia

Indonesia has enacted policies and laws (Omnibus Law on Job Creation) to speed up the transformation of the number of countries, including: Policy on sharing and sharing network infrastructure, fees and auctions. Frequency ("Pay or Play"), 5G model testing and collaboration (Open RAN), skill building and innovation promotion (Digital Talent, IoT Makers Creation), personal data protection, focus on Priority applications for tourism and construction of New Capitals. According to forecasts, Indonesia will need to add at least 1,310 MHz of spectrum to 5G by 2024 and 5G will contribute about US $ 200 billion to GDP, creating about 4.4 million job opportunities by 2030.

1.2.4. Laos

Laos Government is focusing on two major issues on 5G including the national strategy and policy making. Laos policies prioritize on but not limited on the simplification of infrastructure access regulation. Laos has issued policies to support 5G development such as MPT's strategy plan 2016-2025 and Government's strategy plan on radio frequency as well as training on to be ready for IMT- 2020.

1.2.5. Malaysia

In preparing and building the nation towards being 5G ready, MCMC launched the 5G Malaysia Demonstration Projects (5GDP) in October 2019 which aims to catalyse industry transformation by facilitating, building and nurturing development of promising 5G use cases in a live but controlled environment; and in a broader context, grow the 5G ecosystem focusing on 9 key verticals and subsequently, drive the growth of the 5G ecosystem in the country. It also aims to create awareness and stimulate demand for the use of 5G technology.

1.2.6. Myanmar

The Department of MPT Myanmar has been reviewing the Spectrum Roadmap which was released in 2016 and in that reviewed spectrum roadmap, the tentative for the release of 5G spectrum will be mentioned. Myanmar's policies prioritize on but not limited on the simplification of infrastructure access regulation, encouragement of co-investment and risk sharing models.

1.2.7. Philippines

The Philippines recognizes the importance of 5G technology and how it plays a pivotal role in developing the national ICT landscape. Preparations for the 5G commenced since the approval of the National Broadband Plan (NBP) in 2017.

The NBP details strategies and initiatives to address gaps in the broadband environment, particularly on accessibility, affordability, and quality of broadband services, and existing policy and regulatory issues. The plan also lays down an approach in investing in networks as well as engaging the public and private sectors. Specifically, the NBP provides as action points: spectrum, infrastructure policy and modernizing outdated regulations.

Government Support in Driving 5G Ecosystem Development

I. The New Major Telecommunications Player Initiative

The new major telecommunications player initiative has paved the way for the release of 5G spectrum in the 3.3 GHz band, aside from the existing assigned frequencies of the incumbent Telcos in the 3.5 GHz (5G Trials are ongoing in this band).

A. Technology neutral policy enshrined in Republic Act 7925

Aside from the release of 5G spectrum in 3.3 GHz and 3.5 GHz bands, all existing frequency assignments, from 1st Generation (1G) to 4G/LTE frequency bands may also be used for the deployment of 5G services pursuant to the technology-neutral policy which is enshrined in Republic Act 7925 or the Public Telecommunications Policy Act of the Philippines-which allows Mobile Operators to utilize their frequency assignments for the deployment of any available technologies, including 5G.

B. Shared Passive Telecommunications Tower Infrastructure

To expedite the construction of telecommunications towers in the country, the Department of Information and Communications Technology (DICT) promulgated Department Circular No. 008, s. 2020: Guidelines on Shared Passive Telecommunications Tower Infrastructure (PTTI).

Under the Policy on Shared PTTIs, the DICT encourages the growth and development of Independent Tower Companies (ITCs) as a pioneering sector for the birth and development of a robust ICT environment of Shared PTTIs in line with the overall objective of enhancing wireless network coverage and quality of ICT services across the entire country. It seeks to widen the base of tower providers to fast-track the deployment of Shared PTTIs across all regions of the country, especially in the unserved and underserved areas.

In relation to this, an oversight committee for Passive Telecommunications Tower Infrastructure was created and was composed of national government agencies such as the Department of Information and Communications Technology (DICT), Anti-Red Tape Authority (ARTA), Department of the Interior and Local Government (DILG), Department of Human Settlements and Urban Development (DHSUD), Bureau of Fire Protection (BFP), Department of Public Works and Highways (DPWH), Civil Aviation Authority (CAA), National Telecommunications Commission (NTC), Department of Health (DOH), and Food and Drug Administration (FDA). The oversight committee issued Joint Memorandum Circular (JMC) No. 1 series of 2021 on streamlining of the permitting process of shared Passive Telecommunications Tower Infrastructure (PTTIs).

Consequently, a similar oversight committee composed of the Department of Information and Communications Technology (DICT), Anti-Red Tape Authority (ARTA), Department of the Interior and Local Government (DILG), Department of Human Settlements and Urban Development (DHSUD), Department of Public Works and Highways (DPWH), Civil Aviation Authority (CAA), National Telecommunications Commission (NTC), Energy Regulatory Commission (ERC), National Electrification Administration (NEA) and the Philippine Competition Commission (PCC) issued JMC No. 1 Series of 2021 on the streamlined guidelines for the issuance of permits and clearances for the erection of poles, construction of underground fiber ducts and installation of aerial and underground cables and facilities to accelerate the roll-out of telecommunications and internet infrastructure.

The Challenges of 5G Technology in the Philippines

Despite the developments, the following are the challenges of 5G technology in the Philippines:

- Need for rules on the deployment of small cells and national roaming;
- Need for legislative actions to spur the development of the telecommunications industry;
- Need to review the current spectrum users' fees imposed especially on the unused radio frequencies;
- Need to review spectrum policy options to ensure competition and industry sustainability (e.g. spectrum caps); and
- 5G cybersecurity and standards development capability need to be ensured.

1.2.8. Singapore

For the first tranche of 5G spectrum comprising spectrum in the 3.5 GHz and mmWave bands, the Infocomm Media Development Authority (IMDA) allocated spectrum through a Call for Proposal (CFP) process. In June 2020, IMDA selected Singtel Mobile Singapore Pte Ltd and the Joint-Venture Consortium formed by StarHub Mobile Pte Ltd and M1 Limited as the winners of the 5G CFP to deploy nationwide 5G Standalone (SA) networks. The 5G CFP winners were allocated spectrum in both the 3.5 GHz and mmWave bands and are expected to achieve 50% outdoor 5G SA coverage by end-2022, and nationwide (95%) outdoor 5G SA coverage by end-2025. TPG was assigned spectrum in the mmWave band, which is more suited for localised deployments. From January 2021, Singapore started rolling out 5G nationwide; by the end of 2022, it will cover 50% and by 2025 it will cover 95% nationwide. IMDA is now in the process of issuing the second tranche of 5G spectrum (the 2.1 GHz band). This will support the next wave of 5G growth for all mobile operators, including the opportunity for the deployment of additional nationwide 5G networks if there is market demand.

Early 5G trials and development were in strategic clusters such as Maritime Operations, Urban Mobility, Smart Estates, Industry 4.0, Government applications and Consumer applications. In Jan 2021, IMDA launched the 5G Innovation Programme to accelerate the adoption and commercialisation of 5G solutions, to build on the earlier efforts to trial 5G use cases. The fund will support enterprises' efforts to adopt 5G solutions to

address sector challenges or enterprise level needs. The fund will also support solution providers and technology developers commercialising 5G solutions, to help make the benefits of 5G more accessible to more companies, including SMEs.

In July 2021, IMDA and the National Research Foundation (NRF) announced a close to S$70 million fund for Singapore's first Future Communications R&D Programme ("FCP") to support cutting-edge communications and connectivity research, including support for international partnerships and local talents pursuing research in future communications technologies.

In October 2021, IMDA announced that business will have access to open testbeds to develop, adopt and commercialise 5G solutions. The testbeds are located at the Maritime Drone Estate, Singapore Science Park, PIXEL and Sentosa, for businesses of different sizes, industries and technology readiness levels to experiment with and develop 5G solutions in areas such as drone deliveries, maritime operations, smart cities solutions, and content production.

1.2.9. Thailand

The national 5G committee has been established with Prime Minister as chairman and involved ministers and parties as committees to set a 5G strategic direction and establish task groups to help support its work.

The committee has approved of 'the First Phase of Action Plan on the Promotion of 5G Technology Utilisation' which covers 7 years (2021 – 2027). This plan has 4 strategies as follows:

(1). Strategy 1: 5G Infrastructure Development

(2). Strategy 2: 5G for Economic Expansion

(3). Strategy 3: 5G for Social Development

(4). Strategy 4: 5G Ecosystem Acceleration

Since 2019, many activities have been promoted: Band auctions and licensing (low, mid, high-band); applying a "sandbox" policy model for research and testing (5G Testbed) activities at universities; terminal equipment (CPE); management and monitoring of interference issues. In February 2020, Thailand held an auction and licensing for carriers to deploy 5G on the 700MHz, 2.6 GHz and 26 GHz bands. From the fourth quarter of 2020, 5G applications will be commercially deployed, with priority given to key areas such as health, agriculture and smart manufacturing.

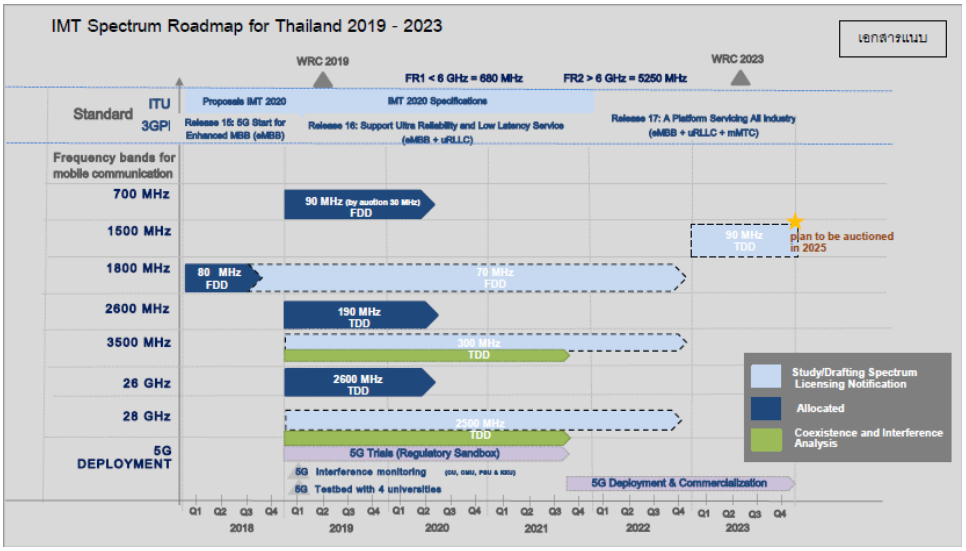


Figure 8. Spectral Planning Roadmap for Thailand's IMT [1]

1.2.10. Viet Nam

The Government of Vietnam has determined that digital infrastructure plays a decisive role in the development of the digital economy and digital society. To meet development needs, telecommunications infrastructure will be transformed into digital infrastructure including telecommunications infrastructure and cloud computing. Vietnam aims to master 5G mobile technology, and master cloud power infrastructure through "Make in Vietnam" platforms. Besides serving socio-economic development, the mastery of digital infrastructure and data ownership of Vietnamese people is a strategic task that should be given top priority. The orientation of the Information and Communication industry in the coming period is to transform from outsourcing to product development. The program "Make in Vietnam", with the focus on research and manufacture of 5G, IoT, smart phones, platforms for national digital transformation. Instead of processing and assembling, Vietnamese enterprises focus on making products.

The Vietnamese government has also issued a series of resolutions and guiding documents related to 5G with the goal of by the 5G mobile network will cover the whole country in the soonest time. The Minister of Information and Communications issued Directives in which specified that "5G mobile communication network in Vietnam should be carried out at the same pace with the first countries in the world". In a view that telecommunications networks as the foundation of platforms. The Ministry of Information and Communications and mobile network carriers have taken specific steps by adopting a phased approach in 5G development to move towards commercialization by 2021. The Ministry of Information and Communications has issued Circulars on the band planning of 2.3 GHz, 2, 6 GHz and 26 GHz for 5G deployment and at the same time also issued the set of technical criteria for terminal equipment, base stations and quality of 5G network services to guide the development of standards of 5G network, evaluation and selection of 5G terminals and base station equipment, preparing for the commercialization of 5G in Vietnam.

Since mid-2019, Viettel, VinaPhone and MobiFone have been licensed by the Ministry of Information and Communications to test 5G technology in a number of major cities. In January 2020, there was a first 5G call on network equipment manufactured by Vietnam (Viettel Hi-tech Corporation) and Viettel is the 6th gNodeB equipment supplier in the world along with Ericsson, Nokia, Huawei, Samsung and ZTE. In November 2020, carriers were also licensed by the Ministry of Information and Communications to deploy commercial 5G trials to prepare for the official commercialization of 5G in the next phase.

Because it is still in the trial operation phase, the commercial 5G network has only been deployed in two major cities, Hanoi and Ho Chi Minh City, particularly as follows:

Viettel network operator was licensed by the Ministry of Information and Communications to test 5G in Hanoi. Viettel's 5G test coverage includes main streets in the three districts of Hoan Kiem, Hai Ba Trung and Ba Dinh. In total, there will be 100 5G base stations deployed by Viettel in the test area in which there are 15 5G stations made by Make in Vietnam products and 85 stations of other mobile vendors. The other mobile network operator, VNPT-VinaPhone, was licensed to test commercial 5G networks in two big cities, Hanoi and Ho Chi Minh city. VinaPhone's 5G coverage in Hanoi covered streets in Hoan Kiem and Hai Ba Trung districts and Ho Chi Minh city

(District 1, around Nguyen Hue flower garden area, Bach Dang wharf, Notre Dame Cathedral, Dong Khoi Street and District 3 along Paster Street, Turtle Lake, Thanh Nien Cultural House... The other mobile network operator, MobiFone, was licensed to test 5G in the Ho Chi Minh city area. Under this license, MobiFone deployed 5G commercial trials in District 1 of Ho Chi Minh city. This operator has completed the installation of about 50 5G stations. MobiFone users can surface the 5G services at 80 Nguyen Du (Ben Nghe Ward, District 1, Ho Chi Minh City) and a few streets around Notre Dame Cathedral.

The deployment of 5G in Vietnam will be based on about 70% of the existing 4G infrastructure, including broadcasting stations, antennas and other transmission equipment, significantly saving costs. The rollout of 5G will take place first in major metropolitan areas, followed by industrial zones, research zones, and universities to support innovation and the creation of new technology. The government is also developing new national technical regulations for ground mobile communication terminals, which require all mobile terminals to be produced, imported and selling in Vietnam will have to support 4G and 5G technology.

2. 5G development outside ASEAN

The current status of 5G advanced countries will be introduced as an example outside ASEAN.

2.1. Japan

Japan's efforts to deploy 5G use are introduced Market scale, Spectrum management, Transition from 4G to 5G, National strategies for Nationwide 5G deployment, Utilizing Local 5G and Features of Japanese 5G model.

- **Market scale**

The utilization of 5G technology for Employment creation, improving regional economic cycle, Regional revitalization and Measures against depopulated areas is estimated to make $700 billion of economic effects in Japan by 2030.

- **Spectrum management**

Japan has implemented frequency allocations at 3.7GHz, 4.5GHz, and 28GHz range in 2018, moving toward widespread 5G services in 2019, and starting local 5G demonstrations in 2020.

Noted that 4.6-4.9GHz and 28.2-29.1GHz bands are scheduled to be assigned for local 5G by the end of 2020.

Since April 2019, Japan has licensed frequencies for carriers to deploy 5G stations nationwide and by certain regions. Because 5G base stations have a small coverage area, if it is required for carriers to deploy "coverage rate by population", many 5G base stations will be needed, leading to huge investment costs, at the same time, low-density rural areas will find it difficult to access 5G soon. Therefore, Japan has come up with a new plan, which will divide the country into geographical areas with an area of 10 square kilometers and install 5G BTS in more than 50% of these 10 square kilometers over the next five years and coverage of potential business areas in both urban and rural areas.

Japan focuses on developing Local / Private 5G, which is a 5G system that can be flexibly built according to areas such as offices, factories; Private 5G network system can be invested and built by domestic enterprises and local governments. A dedicated 5G network is built to support the deployment of digital transformation projects, promoting IoT in production.

The Japanese government has also stepped up promoting the global deployment of 5G network virtualization models (OpenRAN and vRAN) to meet the requirements of network optimization, ensuring network security as well as save implementation costs. Currently, Japanese enterprises (Rakuten, NTT Docomo) are operating very actively in this field.

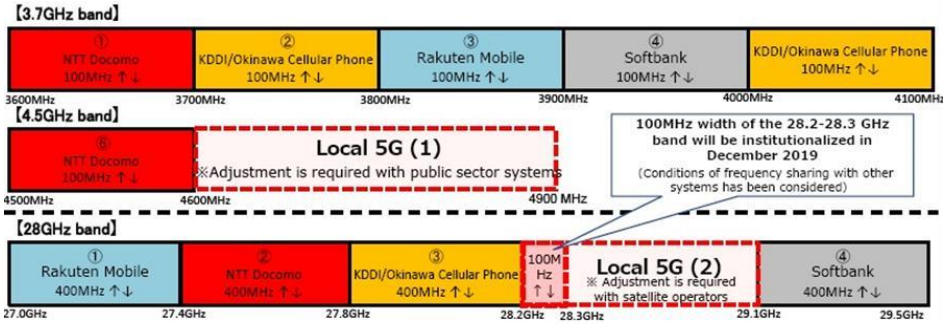


Figure 9. Licensing 5G band in Japan

- **Transition from 4G to 5G**

An important prerequisite for deploying 5G is the development of fiber optic networks. Even with 5G Mobile Network, services can only be provided when the optical fiber network is connected to the base station and core (center) equipment that emit radio waves. In Japan as of March 2020, the household coverage rate for optical fiber networks is around 98%. Even under this situation, the large-capacity optical fiber network for 5G requires further maintenance, and annual investment, about more than 5 billion yen worth. Until 2030, we plan to use the NSA (Non Stand Alone) method to gradually replace the 5G network with 4G facilities.

- **National strategies for Nationwide 5G deployment**

Dividing the Japan into 10 km square meshes and covering a wide range of potential business areas* in both urban and rural areas. (Number of target meshes: about 4,500)
Four mobile phone operators have launched 5G commercial service since March 2020.

1. Expansion of 5G area coverage, mainly in major cities in japan. (2020-2021)
2. Deploying 5G base stations for more than 50% of meshes within five years nationwide and per regional block. (securing the possibility of nationwide expansion)
3. Starting services in all prefectures within two years after spectrum assignment.
4. Deploying as many specified base stations as possible across the country.

When approving additional licenses for the establishment of specific base stations, a focused evaluation will be made regarding the plan for providing services to Mobile Virtual Network Operator (MVNO)

- **Utilizing Local 5G**

Local 5G is a 5G system that can be flexibly built on a spot basis by various entities, such as local enterprises and municipalities, in their own buildings and premises, depending on the specific needs of a region or industry.

< Features of local 5G systems >

1. Unlike the 5G services of mobile operators, local 5G systems can be built ahead of time in areas where mobile operators are slow to deploy their areas.
2. The performance required can be flexibly set according to the intended use.
3. Less susceptible to communication failures in other locations, disasters, etc.

In addition, compared to WiFi, it is characterized by stable use based on the radio station license.

Several demonstration project has been started in 2019 to apply local 5G as a solution to a situation where mobile operators are expected to delay the provision of 5G services.

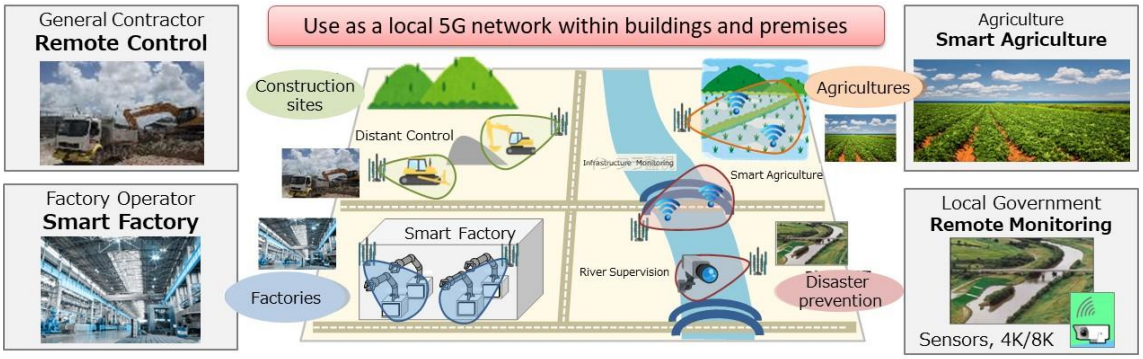


Figure 10. Use of local 5G within buildings and premises in Japan

(Source: MIC Japan 2020)

- **Features of the 5G system that Japan is introducing (Japanese 5G model)**

According to the report provided by MIC Japan, the Japanese 5G model has the following features and advantages.

(1) Open and secure

In the construction of 5G communication network, Japanese vendors preferred openness of radio access network (O-RAN) and separation of hardware and software (vRAN) that allows free combination of devices from various vendors.

O-RAN-compliant open interfaces are used, and the inter-device interfaces are highly transparent from the perspective of security.

- O-RAN

A wireless network that can be constructed in an open and smart way by combining multiple vendors without depending on any particular vendor.

The O-RAN Alliance, in which the world's major carriers and vendors participate, is promoting the development of international standard specifications.

- vRAN

vRAN is a wireless network that combines software and general-purpose hardware, and uses virtualization technology to enable flexible functional expansion and operation. Domestic vendors are also promoting the development of base stations that support virtualization.

In considering 5G development, it is necessary to actively work on getting rid of i.e. legacy type components (ex. avoiding vendor lock in) that has been an obstacle to development. In this sense, the introduction of O-RAN is an urgently needed initiative.
In existing mobile networks, devices from a specific vendor are installed, resulting in "vendor lock-in" that makes it difficult to change the vendor of the device.
By promoting O-RAN, network operators will be able to configure their networks with terminals from multiple vendors, which will promote competition among vendors and lead to lower network prices. As a result, competition among vendors will be promoted, leading to lower network construction costs, stability of supply, and security.
In the tax incentives for the deployment of 5G introduced in August 2020, Openness is set as one of the requirements for incentive to promote multi-vendor in 5G.

(2) High quality

Japanese vendors already have a track record of installation and operation for major domestic carriers (having passed very strict tests).
The Japanese vendor's network equipment is characterized by high efficiency, space-saving, energy-saving, and low operating costs.

(3) Flexibility to meet diverse needs

Because of its openness, it is possible to combine a wide variety of equipment and software required for 5G construction, to meet diverse needs, and to build an optimal network more quickly.
Japan is one of the advanced countries in the world to institutionalize local 5G, and at the same time, Japan has accumulated various use cases through development and demonstration, and has an advantage in providing advice on know-how for overseas deployment.

- **International coordination with AMS**

In light of future 5G development, the Government of Japan has begun to promote the international deployment of O-RAN and vRAN and share information on network openness with relevant AMS.
Japan's 5G model has the strength to meet a wide range of needs, including openness, security, quality, and flexibility.
The Japanese government is working with the Japanese private sector to roll out this 5G model to the global market.

Looking ahead to the 5G era based on the knowledge of advanced countries will greatly contribute to the development of 5G in ASEAN.

2.2. EU

In Europe, the European Union (EU) has issued the Action Plan for 5G deployment (Action Plan) according to major milestones: Announcing 5G in certain areas (2018); commercialization of 5G services in at least one city of the member countries (2020); and 5G is covered in urban areas and major transportation routes among member countries (2025). The EU is implementing 5G according to the roadmap and using the existing core network (Non-Standalone version of 3GPP standard). To date, 16 EU member countries have officially announced 5G networks (more than 30 5G networks are operating on the 700MHz, 3.4-3.8GHz and 26GHz bands), the priority areas: Public security, real virtual reality, energy, healthcare, smart cities, media and entertainment, industry 4.0, transportation, automation and agriculture.

The key issues (EU flagship initiative, Regional Management, Radio Spectrum Management, 5G Action Plan (2020), Issues for 5G Action Plan, International Cooperation) of 5G development in the EU are listed below.

- **EU flagship initiative for 5G development**

Recognizing the importance of 5G development early on, the European Commission established the public-private partnership on 5G (5G PPP) in 2013. This is the EU's most important initiative to accelerate research and innovation in 5G technology. The European Commission has secured €700 million in public funding through its horizon 2020 program to support this activity. In addition to this program, EU industry has plans to invest up to five times as much - €3 billion.

- **Regional Management for 5G deployment**

To ensure the rapid deployment of 5G infrastructure in Europe, the European Commission adopted the European 5G action plan in 2016, which aims to start 5G services in all member states by the end of 2020 at the latest, followed by the expansion of 5G coverage to urban areas and major traffic routes by 2025.

In order to monitor the progress of the 5G action plan, the European Commission launched the European 5G observatory in 2018, a monitoring tool on key European market developments in a global context. It also reports on preparatory actions undertaken by member states, such as spectrum auctions and national 5G strategies. In October 2018, a report was published on the main elements to be considered in such national strategies from a European perspective.

- **Issue of Radio Spectrum Management**

The management of the radio spectrum, which is the basis of wireless technology, is critical to the deployment of 5G networks. As the number of connected devices and their usage increases, there is a need to harmonize spectrum resources and their use across EU area. In particular, the interoperability of cross-border infrastructures makes this intra-regional harmonization a key issue.

- **5G Action Plan (2020)**

The EU 5G Action Plan is a strategic initiative involving all stakeholders, private and public, large and small, in all Member States to meet the challenge of making 5G a reality for all citizens and businesses by the end of 2020. On September 14, 2016, the European Commission announced plans to boost the EU's efforts to deploy 5G infrastructure and services across the Digital Single Market by 2020. The action plan sets out a clear roadmap for public and private investment in 5G infrastructure in the EU. To achieve that, the Commission has proposed proposes the following measures in the roadmap:

① Coordinate the roadmap and priorities for a coordinated 5G deployment in all EU Member States, with the goal of early network deployment by 2018 and moving towards commercial large-scale deployment by the end of 2020 at the latest. (Ongoing in 2020)

② Make available provisional spectrum bands for 5G in advance of the 2019 World Radio Communication Conference (WRC-19), supplemented by additional spectrum as quickly as possible, and work towards a recommended approach for the authorization of specific 5G spectrum bands above 6 GHz.

③ Promote early deployment in major urban areas and along major transportation

corridors.

④ Promote pan-European multi-stakeholder trials as a catalyst for transforming technological innovations into complete business solutions.

⑤ Facilitate the implementation of industry-led venture funds to support 5G-based innovation.

⑥ Unite key actors in the promotion of global standards.

- **Issues for realizing the EU 5G action plan**

Since major research efforts are underway worldwide, it is essential to avoid incompatible 5G standards emerging in different regions. If Europe is to help shape a global consensus as regards the choice of technologies, spectrum bands and leading 5G applications effective, EU coordination and planning on a cross-border basis will be needed. The launch of commercial 5G services will also require significant investment, the availability of the right amount of spectrum, and close collaboration between telecom operators and key user industries. Network operators are unlikely to invest in new infrastructure without a clear prospect of reliable demand and regulatory conditions to match their investments. Similarly, industrial sectors interested in 5G for their digitization processes may want to wait until 5G infrastructure is tested and ready.

In this context, a lack of coordination between national approaches to the deployment of 5G networks poses a significant risk of fragmentation in terms of spectrum availability, continuity of services across borders (e.g. connected vehicles), and implementation of standards.

As a result, it would delay the creation of a critical mass for 5G-based innovation in the Digital Single Market. This is particularly evidenced by the initial delay in the deployment of 4G in Europe: in 2015, more than 75% of the US population had access to 4G/LTE versus only 28% of the EU population.

Despite the fact that the gap has been steadily narrowing, there are still significant differences between Member States. The European Commission has therefore proposed this Action Plan as a means to promote proper coordination. The Action Plan aims to increase Europe's competitiveness and bring tangible benefits to society by building momentum for investment in 5G networks and creating new innovative ecosystems.

This EU precedent will be very helpful for AMS that are working on the 5G action plan and Road Map.

- **International cooperation on 5G**

The EC strongly supports international cooperation towards global interoperability, namely through common standardization and spectrum harmonization.

The future of telecommunications and computing infrastructure connecting billions of users and trillions of devices is requiring more efficient technology to be able to overcome exploding traffic and properly address security issues. This revolution will rely on a common global definition of 5G and associated standards, and of its service characteristics. Only then can we ensure seamless optical and wireless connectivity, interoperable ways to store and access information and computing power (Cloud computing), sensing the world at large (Internet of Things) and ensuring the highest security and energy efficiency.

In line with the EU's strategy for international cooperation in research and innovation (COM (2012)497), international cooperation is encouraged, especially with countries that are advanced in certain fields (e.g. Brazil, China, Japan, Korea, Taiwan, and for 5G, the US). The 5G development is also in line with this trend.

In particular, international cooperation is a critical instrument to arrive at a global consensus on 5G vision, standards and spectrum requirements for 5G. To that end, the European Commission has signed so far Joint Declarations on 5G with Brazil, China, Japan and South Korea. Cooperation is also well established with India and the United States, and informal targeted cooperation is ongoing with Taiwan.

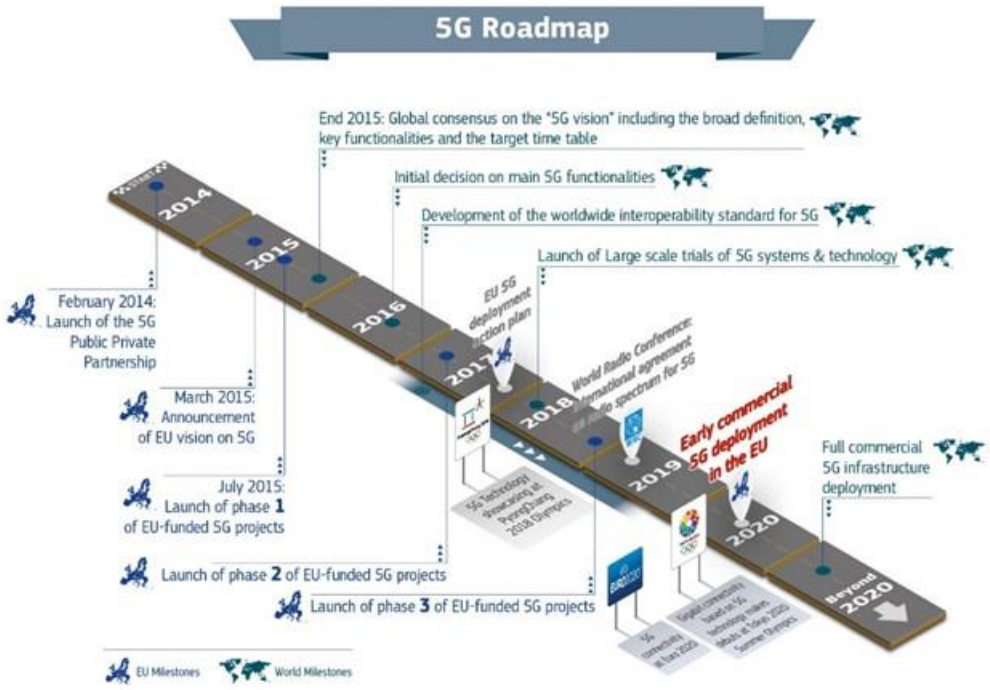


Figure 11. EU 5G Roadmap (2020)

2.3. US

In the United States, in March 2020, the country issued the National Strategy to ensure 5G networks, which promotes domestic 5G deployment: Focusing on releasing more bands (high, mid, low and unlicensed bands) for 5G; update policies on development of wireless network infrastructure; reform and complete regulations to ensure freedom on the Internet, reduce costs and speed up the deployment of 5G backbone networks, convert new generation network protocols, data services,... 5G network security, the United States defines the principles of ensuring core network security; encourage standards, equipment requirements, and services to reduce risks for global supply chains; Applying virtualization models and solutions to the network (OpenRAN).

The 5G strategy of FCC includes three key components: (1) pushing more spectrum into the marketplace; (2) updating infrastructure policy; and (3) modernizing outdated regulations.

a. Pushing more spectrum into the marketplace:

The FCC is taking action to make additional spectrum available for 5G services.

High band: The FCC has made auctioning high-band, millimeter-wave spectrum a priority.

28 GHz band auction (27.5 GHz – 28.35 GHz; 2 x 425 MHz) and 24 GHz band auction (24.25 – 24.45; 25.25 -25.75 GHz; 7 x100 MHz) has been completed since January 2019 and May 2019 respectively.

37 GHz, 39 GHz, and 47 GHz are the largest auction in U.S which released 3.400 megahertz of spectrum into the commercial marketplace. This auction has been completed since March 2020.

The FCC has been working to free up additional 2.75 GHz of 5G spectrum in the 26 and 42 GHz bands.

Mid-band:

- 2.5 GHz auction planned, potentially in 2021
- 3.5 GHz auction completed on August 25, 2020
- 3.7-3.98 GHz "C-Band" auction begins December 8, 2020 (14x20)
- 3.45 – 3.55 GHz auction will provide an additional 100 MHz (5x20 to align with the 3.7 GHz band)

Low band:

- 600 MHz transition from 2016 Broadcast Incentive Auction completed;
- Targeted changes to 600 MHz, 800 MHz, and 900 MHz bands to improve use of low band spectrum for 5G services

Unlicensed band:

- The FCC has opened new frequency bands to create opportunities for Wi-Fi in the 6 GHz, 61-71 GHz and above 95 GHz bands; also taking a fresh and comprehensive look at the 5.9 GHz (5.850-5.925 GHz) band that has been reserved for use by Dedicated Short-Range Communications (DSRC).

b. Updating infrastructure policy:

New construction of wireless communications facilities or collocation on an existing structure requires state or local approval; and compliance with FCC environmental and

historic preservation rules. Since 2017, the FCC has taken steps to accelerate deployment of wireless facilities by removing regulatory barriers to infrastructure deployment. These actions included: (1) Streamlining the wireless infrastructure siting review process; (2) Addressing the conduct of some state & local governments that needlessly slowed down & increased the costs of wireless infrastructure deployments; (3) Modernizing Federal historic preservation & environmental reviews of wireless deployments.

c. Modernizing outdated regulations:

The FCC is modernizing outdated regulations to promote the wired backbone of 5G networks and digital opportunity for all Americans.

- Restoring Internet Freedom: The FCC adopted the restoring internet freedom order, which sets a consistent national policy for internet providers.
- One-touch Make-ready: The FCC has updated its rules governing the attachment of new network equipment to utility poles in order to reduce cost and speed up the process for 5G backhaul deployment.
- Speeding The IP Transition: The FCC has revised its rules to make it easier for companies to invest in next-generation networks and services instead of the fading networks of the past.
- Business Data Services: In order to incentivize investment in modern fiber networks, the FCC updated rules for high-speed, dedicated services by lifting rate regulation where appropriate.

2.4. Korea

In Korea, the first country in the world to officially commercialize 5G in April 2019, ranked 1st in the world in terms of 5G smartphone market share, 3rd in 5G equipment, with a total of 152,000 BTSs and 9,2 million 5G subscribers.

Korea established the 5G+ Strategic Committee with the goal of leading the world in innovation (5G ecosystem), reaching 150 billion USD by 2026, focusing on 10 leading industries. pointed (network equipment, smartphones, VR-AR devices, wearables, smart cameras, flying devices, robots, vehicles to everything-V2X, information security, cloud

computing) and 5 main services (smart factory; self-driving cars; content integration; healthcare and smart city).

In the coming time, South Korea will continue to invest in and improve 5G infrastructure (tax reduction, investment by mobile carriers), forecasting demand for frequency will double by 2026 (around 5,320). MHz), developing smart device and cloud computing policies, ...

2.5. China

The commercialization of 5G in China began on November 2019 with the launch of services by three major telecom operators (China Mobile, China Unicom and China Telecom). However, its coverage area was initially limited.

Since then, 5G policies have been formulated to promote nationwide penetration. In particular, the "Notice concerning Promoting the Accelerated Development of 5G" published by the Ministry of Industry and Information Technology on March 2020 sets out a number of directions for network development and application scenarios. This is the first time in the world that a company has been able to build a base station at a national level. In terms of application scenarios, the government has identified medical and health care, industrial internet, and connected cars as priority areas. In particular, for the Industrial Internet, the necessary technologies will be developed and application standards will be set by 2022. As for 5G operating licenses, Government has also been issued to cable TV operators (China Broad Band) in 2019 for the purpose of introducing the principle of competition.

(1) Strategic Plan for 5G Development

The Chinese market for 5G is undoubtedly the largest in the world, with 1,279.33 million 4G mobile users in China as of May 2020, the foundation for 5G. The Chinese government has reported that by the end of September 2020, the network will have 690,000 base stations and more than 160 million 5G connections, compared to just over 400,000 base stations and 88 million connections at the end of June, indicating rapid development even amidst the chaos of COVID-19. In just three months, both of these numbers have nearly doubled.

The GSMA predicts that China will account for 70% of the world's 5G connections by 2020.

In order to accelerate the construction of 5G networks, the Chinese government has supported the construction of Stand-Alone (SA) networks by telecom companies. This is where the approach differs from Japan, EU, and USA. (Refer Item mentioned above)

In addition, to support the construction of base stations, the central government recommended that local governments incorporate base station construction sites into their national spatial planning, and take base station construction sites into account when planning public transportation. In addition, the government recommended the establishment of a cooperative system between power companies and telecommunication companies so that power can be supplied to the constructed base stations promptly.

As for frequency management, the rules for use of the 700MHz band were formulated, and adjustments were made so that other satellite base stations, etc. would not interfere with 5G base stations.

The most advanced networks are in Shenzhen and Beijing. The city of Shenzhen announced in August 2019 that it had installed more than 46,000 base stations, covering the entire city of Shenzhen. On September 2019, Beijing Communications Regulatory Bureau also announced that it had installed 44,000 base stations and completed coverage of key areas inside and outside the Fifth Ring Road, which runs about 10 kilometers from the center of the city. In both cities, the base stations have been installed in a Stand-Alone (SA) mode, which allows the best performance of 5G. On the other hand, the Non-Stand Alone (NSA) method, which uses the existing 4G facilities being introduced by Japan and other countries, can build the network faster and at lower cost than the SA method, but the existing 4G network becomes a bottleneck, and the disadvantages of 5G such as low latency cannot be fully demonstrated. For this reason, the NSA method has been adopted. For this reason, the NSA method is positioned as a transitional measure for the transition to the SA method.

Under these circumstances, the government encouraged telecom operators to facilitate the migration of users from 4G to 5G by offering set plans for usage fees in order to foster a new consumption style. The government positioned 5G as an important

communication infrastructure that is indispensable for the development of smart cities and smart transportation. In addition, the 5G smart medical system will promote its use in COVID-19 countermeasures, telemedicine, long-distance diagnosis, and diagnostic imaging applications. At the same time, for the industrial Internet, the government plans to develop the necessary 5G technologies and build a public platform by 2022. [8] [9]

ANNEX 2: SURVEY QUESTIONNAIRES AND RESPONSES FROM ASEAN COUNTRIES, JAPAN AND USA ON 5G

1. Introduction

Developing 5G - the next generation of mobile internet connectivity–is of significance to the growth of ASEAN countries as 5G will be the most important part of the infrastructure for the digital economy thanks to its greater bandwidth, higher speeds and lower latency. With the aim to co-develop and shorten the development gap with advanced countries in 5G sector, ASEAN countries need to strengthen co-operation and share their experiences to ensure they can lead the way on next-generation 5G wireless technology.

The purpose of this study aims to facilitate the introduction of 5G in ASEAN countries through best practice guide sharing, which will in turn to support the development of ASEAN citizens with the latest infrastructure and technology, applications and services to enhance the quality of life for ASEAN.

2. Objective

The objective of this survey is to:

(i) understand the current status and challenges of AMS in regard to 5G ecosystem development;
(ii) exchange the ideas and initiatives to support AMS in the development of 5G ecosystem;
(iii) get the responses of AMS and its Dialogue Partners on the key issues of study;
(iv) design the agenda and the content for its expert meeting.

3. Summary

The responses of AMS and its Dialogue Partners have been collected **at the end of October 2020** and summarized in the table below.

QUESTIONS	BRUNEI	CAMBODIA	INDONESIA	LAOS	MALAYSIA [updated as of Jan. 2022]	MYANMAR
General issues						
Question 1. Could you please share your view on what 5G might bring to your country?	☒ Meeting traffic & connectivity demand ☒ Contributing to the national digitalization transformation ☒ Solve the social problem: ☒ Transportation ☒ Logistics ☒ Environment ☒ Education ☒ Medical, healthcare ☒ Manufacturing ☒ Natural disasters ☒ Anti-terorism, crime	☒ Contributing to the national digitalization transformation	☒ Meeting traffic & connectivity demand ☒ Contributing to the national digitalization transformation ☒ Manufacturing ☒ Others. Please specify in detail:… Ø Accelerating fixed broadband penetration to households Ø Tourism and digital infrastructure at the new capital city	☒ Meeting traffic & connectivity demand ☒ Contributing to the national digitalization transformation ☒ Solve the social problem: ☒ Transportation ☒ Logistics ☒ Education ☒ Natural disasters	☒ Meeting traffic &connectivity demand ☒Contributing to the national digitalization transformation ☒Improve the social services and facilities: ☒Transportation ☒Logistics ☒Environment ☒Education ☒Medical, healthcare ☒Manufacturing ☒Others. Please specify in detail: For Malaysia, 5G is an economic imperative that holistically influences the quality of life, businesses including small and medium-sized enterprises, as well as the government. In Malaysia, development of solutions are focused in nine (9) key verticals i.e.: Agriculture, Digital Healthcare, Education, Entertainment/Media, Manufacturing &	☒ Meeting traffic & connectivity demand ☒ Contributing to the national digitalization transformation

QUESTIONS	BRUNEI	CAMBODIA	INDONESIA	LAOS	MALAYSIA [updated as of Jan. 2022]	MYANMAR
					Processing, Oil & Gas, Smart City,Smart Transportation, Tourism.These verticals are seen directly correlated to the country's economic growth.	
Question 2. Could you please share your view on how important it is for ASEAN in general and your country in specific to have a policy framework or action plan on 5G development?	☒ Extremely important	☒ Extremely important	☒ Very important	☒ Extremely important	☒Extremely important	☒Very important
Question 3. Which the following issues you think will benefit from ASEAN's action programs and/or roadmap on 5G development?	☒ Sharing the current status of 5G development at AMS (as of October 2020) ☒ Sharing cases of leading ASEAN countries ☒ Introduction of use cases in 5G	☒ Sharing the current status of 5G development at AMS (as of October 2020) ☒ Introduction of use cases in 5G developed countries	☒ Sharing the current status of 5G development at AMS (as of October 2020) ☒ Sharing cases of leading ASEAN countries ☒ Introduction of use cases in	☒ Sharing the current status of 5G development at AMS (as of October 2020) ☒ Sharing cases of leading ASEAN countries ☒ Introduction of use cases in 5G developed countries	☒Sharing the current status of 5G development at AMS (as of October 2020) ☒Sharing cases of leading ASEAN countries ☒Introduction of use cases in 5G developed countries ☒Basic concept of LOCAL 5G	☒Sharing the current status of 5G development at AMS (as of October 2020) ☒Introduction of use cases in 5G developed countries

QUESTIONS	BRUNEI	CAMBODIA	INDONESIA	LAOS	MALAYSIA [updated as of Jan. 2022]	MYANMAR
	developed countries		5G developed countries		Knowledge sharing and development of harmonised framework on policies for cloud,data, device, digital services, privacy and security as well as policy on specific vertical.	
Policy framework on 5G development:						
Question 4. In which areas of 5G your country is focusing on?	☒ National strategy ☒ Establishment of 5G task group ☒ Policy making ☒ R&D ☒ Others. Please specify in detail: 5G Proof of Concept	☒ National strategy ☒ Establishment of 5G task group ☒ Policy making	☒ National strategy ☒ Establishment of 5G task group ☒ Policy making	☒ National strategy ☒ Policy making	☒National strategy ☒Establishment of 5G task group ☒Policy making ☒R&D ☒Real world use cases	☒Policy making
Question 5. Is a 5G task group active in your country?	☒ Yes. Please specify in detail: The taskgroup consists of representatives from government agencies, vendors, TelCos, academia and private sectors which further	☒ Yes. Please specify in detail: we are planning 5G roadmap and policy for infrastructure sharing	☒ Yes. Please specify in detail:…. Ø The 5G Task Force consists of Secretariat, Group of Experts, and 5 Working Groups covering the	☒ No	☒Yes. The Malaysian Communications and Multimedia Commission (MCMC) established a National 5G Task Force in November 2018 to study and recommend a holistic strategy for the deployment of the 5	☒No

QUESTIONS	BRUNEI	CAMBODIA	INDONESIA	LAOS	MALAYSIA [updated as of Jan. 2022]	MYANMAR
	divided into 3 subgroups looking into: 1. Policy, Regulatory and Spectrum 2. Uses cases, Application Development and Infrastructure 3. Education and Awareness The taskforce will be responsible to provide a final report which contains proposals and recommendations in facilitating 5G implementation in Brunei Darussalam in twelve (12) months after its establishment.		issues of spectrum, business model, infrastructure, device & ecosystem, and modernizing the regulations. Ø Group of Experts consists of representatives from academia and private sector such as telco operators and equipment vendors. Secretariat and Working Groups consist of representatives from the Ministry of Communications and Informatics (MCI).		Generation (5G) mobile internet in Malaysia. A collaborative effort with relevant stakeholders, the 5G Task Force comprises of members from the private sector, Ministries, and agencies representing the demand and supply side of the ecosystem. The 5G Task Force was divided into 4 Working Groups with specified focus are as namely Business Case Working Group, Infrastructure Working Group,Spectrum Management and Allocation Working Group & Regulatory Working Group.The 5G Task Force has completed the study and has produced a final report for the MCMC and Minister of Communications and Multimedia.The report produced as an outcome of the Task Force study can be found on MCMC's website.	

QUESTIONS	BRUNEI	CAMBODIA	INDONESIA	LAOS	MALAYSIA [updated as of Jan. 2022]	MYANMAR
Question 6. Does your country promulgate any national plans and/orstrategies on 5G development? If yes, please specify in detail by providing their key points.	☒ Under study	☒ Under study	☒ Under study	☒ Yes.	Yes, in preparing and building the nation towards being 5G ready, MCMC launched the 5G Malaysia Demonstration Projects (5GDP) in October 2019 which aims to catalyse industry transformation by facilitating, building and nurturing development of promising 5G use cases in a live but controlled environment; and in a broader context, grow the 5G ecosystem focusing on 9 key verticals and subsequently, drive the growth of the 5G ecosystem in the country. It also aims to create awareness and stimulate demand forthe use of 5G technology. In February 2021, the Malaysian Government announced that 5G network and services to be implemented by a Government owned entity. It will build a 5G wholesale network and offer equitable access to	☒Yes. Please specify in detail by attaching the relevant materials. The department has been reviewing the Spectrum Roadmap which was released in 2016 and in that reviewed spectrum roadmap, the tentative for the released of 5G spectrum will be mentioned.

QUESTIONS	BRUNEI	CAMBODIA	INDONESIA	LAOS	MALAYSIA [updated as of Jan. 2022]	MYANMAR
					all retail service providers.	
Question 7. Which following matters you think should prioritize in the development of spectrum policies on 5G ?	☒ Making the frequency bands available for 5G use (removal of incumbent radio systems, spectrum allocation and licensing, etc.) ☒ Division of roles between public and private sectors ☒ Institutional development for accelerating 5G utilization speed		☒ Making the frequency bands available for 5G use (removal of incumbent radio systems, spectrum allocation and licensing, etc.) ☒ Others. Please specify in detail:… Ø A rational spectrum fee; Ø Deployment obligation as part of the spectrum license; Ø Support from the wide range of microwave link frequency bands for backhauling, such as E Band and V Band.	☒ Making the frequency bands available for 5G use (removal of incumbent radio systems, spectrum allocation and licensing, etc.)	☒ Making the frequency bands available for 5G use (removal of incumbent radio systems, spectrum allocation and licensing, etc.)	☒Making the frequency bands available for 5G use (removal of incumbent radio systems, spectrum allocation and licensing, etc.)

QUESTIONS	BRUNEI	CAMBODIA	INDONESIA	LAOS	MALAYSIA [updated as of Jan. 2022]	MYANMAR
Question 8. Has your country announced any national roadmaps regarding the licensing of the frequency bands for 5G?	☒ Under study.	☒ Under study	☒ Under study.	☒ Under study.	☒ MCMC has determined the following frequency bands for 5G use and via the apparatus assignment approach: a) 700 MHz (703 – 743 MHz paired with 758 – 798 MHz); b) 3.5 GHz (3.4 – 3.6 GHz); and c) 28 GHz (26.5 – 28.1 GHz)	☒Under study.
Question 9. Which following matters you think should prioritize in the development of policies on 5G network and infrastructure?	☒ Simplification of infrastructure access regulation ☒ Security measures (information sharing, budget securing) ☒ Security measures (technical aspects of 5G introduction)		☒ Simplification of infrastructure access regulation ☒ Encouragement of co-investment and risk sharing models ☒ Security measures (information	☒ Simplification of infrastructure access regulation		☒Simplification of infrastructure access regulation ☒Encouragement of co-investment and risk sharing models

QUESTIONS	BRUNEI	CAMBODIA	INDONESIA	LAOS	MALAYSIA [updated as of Jan. 2022]	MYANMAR
	☒ C / B (Cost / Benefit Analysis)		sharing, budget securing) ☒ Others (descript freely) If there are specific issues faced by each country, please describe in the free description section. Ø Accelerate fiberisation for backbone and backhaul, Ø Harmonizing the policy in the central government with the local governments to facilitate easiness of deploying 5G networks, especially for the passive infrastructure such as ducting, poles, and towers. Ø Modernizing the fundamental			

QUESTIONS	BRUNEI	CAMBODIA	INDONESIA	LAOS	MALAYSIA [updated as of Jan. 2022]	MYANMAR
			regulations to allow and support network sharing and spectrum sharing policies.			
Question 10. What does your country do to support 5G research and development? Please describe the current situation as detailed as possible regarding specific efforts (division of roles between public and private sectors, possibility of collaboration, etc.), training of specialized engineers, and technical cooperation with other countries or private companies	Recognising the importance of collaboration with the industry, AITI has introduced a Regulatory Sandbox to facilitate 5G proof of concept and uses cases. The initiative is to also minimize regulatory barriers and encourage innovation on the potential benefits and applications of 5G whereby, AITI is exempting license fees such as frequency application, Frequency usage, Apparatus Licenses, import permit and Type approval.	§ Study possible use case for 5G and role of partnership between public and private sectors. § Plan to implement IoT on 4G and then 5G § Policy for infrastructure sharing § Spectrum allocation for 5G	Ø Fostering local ecosystem of IoT makers; Ø Bridging the cooperation with leading global initiative to develop Open RAN laboratory in one of Indonesia's reputable university Ø Provide free training of future digital skills to the young people under Digital Talent Scholarship program; Ø Assisting new startups to learn from other forerunners and Indonesian	we have policy to support 5G development such as MPT's strategy plan 2016-2025 and Government's strategy plan on radio frequency as well as training on to be ready for IMT-2020.	In the National Budget 2020, the Malaysian government announced a 5G ecosystem development grant of RM50mil to stimulate adoption of 5G use cases and another RM25mil matching grant fund to spur pilot's projects on digital applications.	Joint study with Academia and stakeholders for 5G Research & Development.

QUESTIONS	BRUNEI	CAMBODIA	INDONESIA	LAOS	MALAYSIA [updated as of Jan. 2022]	MYANMAR
	As part of 5G Taskforce deliverables, AITI has also released call for collaboration to any interested parties to showcase 5G use cases. Successful parties will benefit from the regulatory sandbox as well. There are currently 5 5G covered sites in Brunei which is made available to explore potential 5G use cases and proof of concept. This is initiatives made by the Ministry of Transport and Infocommunications with infrastructure provider, Unified		leading unicorns to stimulate innovations, including 5G use cases; Ø Conducting several 5G trials and showcases.			

QUESTIONS	BRUNEI	CAMBODIA	INDONESIA	LAOS	MALAYSIA [updated as of Jan. 2022]	MYANMAR
	National Networks Sdn Bhd.					
Question 11. What are your views on the importance of acquiring network security in 5G?	☒ Extremely important	☒ Very important	☒ Very important	☒ Very important	☒Extremely important	☒Very important
Question 12. Does your country have any standards or regulations or requirements on cyber security for telecommunications businesses, businesses that build commercial 5G-related software and products ?	☒ Under study.	☒ Under study	☒ Under study.		☒Under study	☒Under study.
5G ecosystem development						

QUESTIONS	BRUNEI	CAMBODIA	INDONESIA	LAOS	MALAYSIA [updated as of Jan. 2022]	MYANMAR
Question 13. What solutions have been and will be applied to promote digital transformation (ie. Digital Government, Digital Economy, Digital Society ...) in your country ?	Digital Economy Masterplan	Create 5G use case related to digital platform	Ø Specifying the target of additional spectrum for mobile broadband in the National Middle Term Development Plan 2020-2024 Ø Establishment of the Omnibus Law regarding Job Creation which also acts as an updated law for the telecommunication sector and determined the Analog Switch Off (ASO) Ø e-Government national program covering all the government institutions, including local governments Ø National data center Ø Digital		Among major initiatives in Malaysia are: ·Digital Economy Blueprint ·Malaysia Digital Economy Task Force (MDET) ·National Regulatory Sandbox ·National Technology Innovation Sandbox (NTIS) ·National Digital Infrastructure Lab (NDIL) ·Services Sector Blueprint 2021-2025 ·Study on National Policy Framework for the 4IR	In order to promote development in social affairs, education, health and economy by the use of digital technology, a Digital Economy Development Committee (DEDC) was formed to perform the tasks of effective implementation of national economic policies, provision of governmental support for the emergence of digital economy in the country (Myanmar).

QUESTIONS	BRUNEI	CAMBODIA	INDONESIA	LAOS	MALAYSIA [updated as of Jan. 2022]	MYANMAR
			literacy program Ø Digital Talent Scholarship Ø IoT Makers Creation (WSIS Prizes 2020 Nominated Project)			
Question 14. What 5G use cases do you see as benefiting the most from 5G ?Also, if there is a use case or model country that your country is referring to as a country that is currently leading the 5G development, please list it. Also, please describe the reason or background for choosing such case or country.	Under study	I think the use cases that benefiting the most from 5G are: § Disaster management § Waste management § Water monitoring § Smart security § Smart agriculture, etc	Ø Mobile Broadband Ø Fixed Wireless Access Ø Industrial automation Ø Smart tourism Ø Smart city	The most benefit from 5G is national connectivital	We believe every 5G use case has its own potential and benefits. As for Malaysia, the5G development are focused in the deployment of use cases in nine (9) industry verticals where it is believed to make the most impact (economy &social), namely; Agriculture, Digital healthcare, Education, Entertainment/Media, Manufacturing & Processing, Oil & Gas, Smart City, Smart Transportation, Tourism.	Transportation & Energy sector will be most benefit for 5G.
Obstacles to 5G						

QUESTIONS	BRUNEI	CAMBODIA	INDONESIA	LAOS	MALAYSIA [updated as of Jan. 2022]	MYANMAR
Question 15. Which of the following issues you think are the challenges need to resolve in order to promote 5G ecosystem?	☒ Utilization of backbone NETWORK ☒ 5G platform construction ☒ Gap between future image and reality for 5G ecosystem ☒ Utilization of backbone NETWORK ☒ 5G platform construction ☒ Gap between future image and reality for 5G ecosystem	☒ Utilization of backbone NETWORK ☒ Gap between future image and reality for 5G ecosystem	☒ Utilization of backbone NETWORK ☒ Latent digital division between urban and rural areas ☒ Security measures ☒ Others. Please specify the issue in detail: …. Ø Spectrum availability Ø Ecosystem maturity Ø Empowering young people with digital skills Ø Creation of a 5G-specific application to boost the demand	☒ Utilization of backbone NETWORK ☒ Gap between future image and reality for 5G ecosystem ☒ Latent digital division between urban and rural areas ☒ Security measures ☒ Fostering 5G experts	☒ Gap between future image and reality for 5G ecosystem	☒ Utilization of backbone NETWORK
Initiatives on 5G						
Question 16. Do you have any proposal or initiatives on	Sharing of potential use cases in 5G development among AMS.	Discuss on band plan for 5G (especially along the	No proposal at the present moment.	We propose ASEAN to ensure the coordination between neighboring	Member countries may work together in promoting the adoption of successful initiatives	Not Yet

QUESTIONS	BRUNEI	CAMBODIA	INDONESIA	LAOS	MALAYSIA [updated as of Jan. 2022]	MYANMAR
how to promote the development of 5G in ASEAN?	Sharing of challenges in deploying 5G i.e. policy framework, infrastructure sharing, cost of deployment, demand on private network).	border) to prevent the interference		countries to avoid interference.	implemented in their respective countries. Outcome of their successful initiatives could potentially form cross-country collaboration paving way for a larger and dynamic ecosystem development. Knowledge sharing and development of harmonised framework on policies for cloud, data, device, digital services, privacy and security as well as policy on specific vertical.	

QUESTIONS	PHILIPPINES	SINGAPORE	VIETNAM	THAILAND	JAPAN	USA
General issues						
Question 1. Could you please share your view on what 5G might bring to your country?		☒ Meeting traffic & connectivity demand ☒ Contributing to the national digitalization transformation ☒ Solve the social problem: ☒ Transportation ☒ Logistics	☒ Meeting traffic & connectivity demand ☒ Contributing to the national digitalization transformation ☒ Solve the social problem: ☒ Transportation ☒ Logistics ☒ Environment ☒ Education	☐ Meeting traffic & connectivity demand ☒ Contributing to the national digitalization transformation ☒ Solve the social problem: ☒ Transportation ☒ Logistics ☒ Education	☒ Meeting traffic & connectivity demand ☒ Contributing to the national digitalization transformation ☒ Solve the social problem: ☒ Transportation ☒ Logistics ☒ Environment	☒ Meeting traffic & connectivity demand

QUESTIONS	PHILIPPINES	SINGAPORE	VIETNAM	THAILAND	JAPAN	USA
		☒ Environment ☒ Education ☒ Medical, healthcare ☒ Manufacturing ☒ Anti-terorism, crime	☒ Medical, healthcare ☒ Manufacturing ☒ Natural disasters ☒ Anti-terorism, crime	☒ Medical, healthcare ☒ Manufacturing ☒ Others. Please specify in detail: 5G network will support applications for various vertical sectors such agricultural, energy, media and entertainment which will contribute to Thailand's GDP growth.	☒ Education ☒ Medical, healthcare ☒ Manufacturing ☒ Natural disasters ☒ Anti-terorism, crime	
Question 2. Could you please share your view on how important it is for ASEAN in general and your country in specific to have a policy framework or action plan on 5G development?		☒ Very Important	☒ Very important	☒ Very important	☒ Extremely important	☒ Extremely important
Question 3. Which the following issues you think will		☒ Sharing the current status of 5G development at	☒ Sharing the current status of 5G development at AMS	☒ Sharing the current status of 5G development at	☒ Sharing the current status of 5G development at	☒ Sharing the current status of 5G development at

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benefit from ASEAN's action programs and/or roadmap on 5G development?		AMS (as of October 2020) ☒ Sharing cases of leading ASEAN countries ☒ Introduction of use cases in 5G developed countries	(as of October 2020) ☒ Sharing cases of leading ASEAN countries ☒ Introduction of use cases in 5G developed countries ☒ Basic concept of LOCAL 5G	AMS (as of October 2020) ☒ Sharing cases of leading ASEAN countries ☒ Introduction of use cases in 5G developed countries	AMS (as of October 2020) ☒ Sharing cases of leading ASEAN countries ☒ Introduction of use cases in 5G developed countries ☒ Basic concept of LOCAL 5G	AMS (as of October 2020) ☒ Sharing cases of leading ASEAN countries ☒ Introduction of use cases in 5G developed countries ☒ Basic concept of LOCAL 5G ☒ Other comments, please specify: It is important that ASEAN countries develop a framework to address cybersecurity issues and promote the use of trusted vendors leveraging globally accepted practices like the Prague Proposals. In addition, it is important that ASEAN's 5G framework recognize the importance of

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						developing a competitive, innovative, open, interoperable, reliable and secure ecosystem for 5G. A vibrant, interoperable 5G ecosystem establishes a substantial foundation for the development of the future digital economy, including AI, cloud computing, and open data flows.
Policy framework on 5G development:						
Question 4. In which areas of 5G your country is focusing on?		☒ Policy making ☒ R&D	☒ National strategy ☒ Establishment of 5G task group ☒ Policy making ☒ R&D ☒ Detailed legislation	☒ National strategy ☒ Establishment of 5G task group ☒ R&D	☒ National strategy ☒ Policy making ☒ R&D ☒ Detailed legislation	☒ National strategy ☒ Policy making ☒ R&D ☒ Detailed legislation
Question 5. Is a 5G task group active in your country?		☒ Under establishment	☒ Yes. Please specify in detail: a group formed by many experts from various regulatory acengies	☒ Under establishment	☒ Yes. Please specify in detail:…. Technical study on 5G/Local 5G is conducted in "New	☒ No

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			and telcos as well. This group was established by the Minister.		Generation Mobile Communication System Committee" organized under "Information and Communication Council" which is the Minister's advisory body	
Question 6. Does your country promulgate any national plans and/orstrategies on 5G development? If yes, please specify in detail by providing their key points.		☒ Yes. Please specify in detail by attaching the relevant materials. In January 2021, IMDA launched the 5G Innovation Programme to accelerate the adoption and commercialisation of 5G solutions, to build on the earlier efforts to trial 5G use cases. The fund will support enterprises' efforts to adopt 5G solutions and to address sector challenges or enterprise level needs. The fund will also support solution providers	☒ Under study	☒ Yes. Please specify in detail by attaching the relevant materials. The national 5G committee has been established with Prime Minister Prayut Chan-o-cha as chairman and involved ministers and parties as committees to set a 5G strategic direction and establish task groups to help support its work. The committee has approved of 'the First Phase of Action Plan on the Promotion of 5G Technology Utilisation' which	☒ Yes. Please specify in detail by attaching the relevant materials. "Action Plan of the Growth Strategy"(2020) describes as follows "In addition to starting 5G service in all prefectures by the end of FY2020, the 5Gdevelopment plan to FY2024 will be accelerated in order to develop the nationwide 5G networks and promote its utilization." (The document can be found in the following URL: https://www.kantei.g	☒ Yes. Please specify in detail by attaching the relevant materials. FCC's 5G FAST Plan: https://www.fcc.gov/5G. U.S. National Strategy to Secure 5G: https://www.whitehouse.gov/wpcontent/uploads/2020/03/National-Strategy-5G-Final.pdf. USAID Digital Strategy, https://www.usaid.gov/usaid-digital-strategy

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		and technology developers commercialising 5G solutions, to help make the benefits of 5G more accessible to companies, including SMEs.		covers 7 years (2021 – 2027). This plan has 4 strategies as follows: 1. Strategy 1 5G Infrastructure Development 2. Strategy 2 5G for Economic Expansion 3. Strategy 3 5G for Social Development 4. Strategy 4 5G Ecosystem Acceleration	o.jp/jp/singi/keizaisaisei/pdf/ap2020en.pdf)	
Question 7. Which following matters you think should prioritize in the development of spectrum policies on 5G ?		☒ Making the frequency bands available for 5G use (removal of incumbent radio systems, spectrum allocation and licensing, etc.) ☒ Public awareness on the health effects of 5G radio radiation on the human body ☒ Division of roles between public and private sectors	☒ Making the frequency bands available for 5G use (removal of incumbent radio systems, spectrum allocation and licensing, etc.) ☒ Public awareness on the health effects of 5G radio radiation on the human body ☒ Institutional development for accelerating 5G utilization speed	☒ Making the frequency bands available for 5G use (removal of incumbent radio systems, spectrum allocation and licensing, etc.) ☒ Public awareness on the health effects of 5G radio radiation on the human body	☒ Making the frequency bands available for 5G use (removal of incumbent radio systems, spectrum allocation and licensing, etc.)	☒ Making the frequency bands available for 5G use (removal of incumbent radio systems, spectrum allocation and licensing, etc.) ☒ Others. Please specify in detail: Please refer to the FCC's 5G FAST Plan. (The United States will provide additional details during the FCC's presentation at the upcoming ASEAN

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		☒ Others. Please specify in detail:… Spectrum harmonization and coordination with neighbouring countries				Conference on 5G Development.)
Question 8. Has your country announced any national roadmaps regarding the licensing of the frequency bands for 5G?		☒ Yes. Please specify in detail:….Please refer to IMDA's Decision on 5G Mobile Services and Networks issued on 17 Oct 2019, Table 1 page 9, which provides the availability of bands identified for 5G services.	☒ Under study.	☒ Yes. Please specify in detail: NBTC has approved a 5-year IMT spectrum roadmap over the period 2019 – 2023, which dictates timelines for the 700 MHz, 1500 MHz, 1800 MHz, 2600 MHz, 3400 – 3700 MHz, 26 GHz, and 28 GHz bands. The 700 MHz, 2600 MHz, and 26 GHz bands were sold in the auction on February 2020 and the upcoming spectrum bands for	☒ Yes. Please specify in detail:…. MIC announced "Draft Establishment guideline of specified base station for introduction of 5G" in November 2018. After public consultation of the draft guideline, the guideline was promulgated in January 2019. After Frequency assignment application and examination, frequency assignments were	☒ Yes. Please specify in detail: Please refer to the FCC's 5G FAST Plan. (The United States will provide additional details during the FCC's presentation at the upcoming ASEAN Conference on 5G Development.)

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				the next auction will be 3500 MHz and 28 GHz bands, which are prime 5G bands. However, the auction of 3500 MHz would be delayed because it takes quite some time to move existing satellite users out of 3400 – 3700 MHz band. Thus, NBTC is currently revising the roadmap so that it is in line with the spectrum reclamation plan. South Korea auctioned and assigned 3420 - 3700 MHz in 2018 for 5G use, and endeavor to reclaim 3700 - 4000 MHz back from satellite communications so that it can have more available spectrum for 5G.	done in April 2019 to four operators.	
Question 9. Which			☒ Simplification of infrastructure access	☒ Simplification of infrastructure access	☐ Simplification of infrastructure access	☒ Others (descript freely): Please refer

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following matters you think should prioritize in the development of policies on 5G network and infrastructure?			regulation ☒ Encouragement of co-investment and risk sharing models ☒ Under study.	regulation ☒ Encouragement of co-investment and risk sharing models ☒ Security measures (information sharing, budget securing) ☒ C / B (Cost / Benefit Analysis) There are some issues that many countries have thought about. 1. Incentive regulation/initiative/ program to encourage operators to share network for fibre backhaul. 2. Public vs private 5G network. Laws and regulations that support 5G network rollout. 3. The rollout obligation imposed on the licensees.	regulation ☐ Encouragement of co-investment and risk sharing models ☐ Security measures (information sharing, budget securing) ☐ Security measures (technical aspects of 5G introduction) ☐ C / B (Cost / Benefit Analysis) ☒ Others (descript freely) All above items are important and it is not appropriate to List by order of priority.	to the strategies referenced in the response to Question 6. The FCC's 5G FAST Plan, for example, includes three key components; in addition to making more spectrum available for 5G services, the strategy prioritizes updating infrastructure policy to encourage the private sector to invest in 5G networks, as well as modernizing outdated regulations to promote fiber deployment (the wired backbone of 5G networks). The U.S. National Strategy to Secure 5G prioritizes assessing the risks and identifying core security principles for 5G infrastructure;

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						managing the risks to economic and national security from the use of 5G infrastructure; and promoting responsible global development and deployment of 5G infrastructure.
Question 10. What does your country do to support 5G research and development?Please describe the current situation as detailed as possible regarding specific efforts (division of roles between public and private sectors, possibility of collaboration, etc.), training of specialized engineers, and technical cooperation with		In July 2021, IMDA and the National Research Foundation (NRF) announced a close to S$70 million fund for Singapore's first Future Communications R&D Programme to support cutting-edge communications and connectivity research, including support for international partnerships and local talents pursuing research in future communications technologies.	Political commitment, early adoption and proactive approach (prepare spectrum allocation, 5G make in Viet Nam, switch off legacy network, drafting technical guideline, promote smartphone penetration, facilitate infrastructure sharing,…)	1. The government has supported R&D in private sector by allowing companies to have tax reduction on 3 times the cost of their R&D expenditures. The National Science and Technology Development Agency will evaluate candidate companies by applying the defined definitions of basic research, applied research, and product development testing used by the Revenue Department. 2. The national 5G committee has approved three pilot	In Japan, in 2014, the Fifth Generation Mobile Communication Promotion Forum (5GMF) was established to for the purpose of conducting 5G R&D, promoting 5G and so on.（https://5gmf.jp/en/）MIC and 5GMF cooperate with each other to integrally support 5G R&D.	The U.S. government aims to facilitate a regulatory enabling environment that supports industry-driven, private sector led 5G research and development. For example, the FCC has long maintained a robust experimental licensing program, typically granting more than 2,000 experimental licenses per year – many 5G related services and technologies deployed today were first tested

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other countries or private companies				projects using 5G technology: Smart agricultural scheme at the Doi Tung development project area, Chiang Rai, smart agricultural scheme at the Roi Jai Rak project area in Chiang Mai, and smart hospital project at Siriraj Hospital, Bangkok. 3. Thailand Ministry of Digital Economy and Society (MDES), Digital Economy Promotion Agency (Depa) and Huawei have opened Thailand 5G Ecosystem Innovation Center (5G EIC) at Depa headquarter to research 5G use cases and incubate local small and medium-sized enterprises and startups. Huawei has an investment plan to develop a 5G EIC which includes		under the experimental licensing program. In September 2019, in an extension of the experimental licensing program, the FCC announced the creation of its first two Innovation Zones (New York City and Salt Lake City), city-scale test beds for advanced wireless communications and network research, including 5G networks.

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				equipment and expert training, and Depa has goal to do business matching with startups, train workers, and develop innovations. 4. The Office of the NBTC has signed MOUs on 5G testing centre with 4 universities. The purposes of the MOUs are to establish 5G Testbed and Innovation Center, and develop use cases for public benefits and commercial potentials. 5. Broadcasting and Telecommunications Research and Development Fund for Public Interest (BTFP), under the National Broadcasting and Telecommunications Commission (NBTC) will grant fund to offerors for 5G research projects		

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				such as the study project on providing public policy on spectrum sharing management between IMT and the other use in the 3500 MHz and 28 GHz bands, the study project on impact of atmosphere and plasma bubbles on real-time positioning of 5G and drone, and the capacity building project on 5G.		
Question 11. What are your views on the importance of acquiring network security in 5G?		☒ Extremely important	☒ Very important	☒ Extremely important	☒ Extremely important	☒ Extremely important
Question 12. Does your country have any standards or regulations or requirements on cyber security for telecommunications businesses,		☒ Yes. Please specify in detail: Policies and regulations are in place to ensure the cybersecurity of telecom networks, including 5G networks.	☒ Under study.	☒ No.	☒ Yes. Please specify in detail:…. Operators are required to implement adequate cybersecurity measures, including measures against supply chain risks as a condition to obtain	☒ Yes. Please specify in detail: Given the transformational nature of these technologies, procurement and deployment decisions made now will have a

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businesses that build commercial 5G-related software and products ?					the approval of nationwide 5G deployment plans and the local 5G licenses. There are several security standards that operators has to take into account as follows - Info-Communications Safety and Reliability Standards (Notice) - Common standards for information security measures of government agencies and related agencies(FY2018) - Procurement policy and procurement procedure for national goods or services related to IT procurement	generational impact on security, the economy, human rights, and citizen privacy. There can be no trust when a company lacks judicial recourse to resist government overreach. The U.S. Government applies this principle of trust to the development and deployment of next generation 5G networks. In 5G deployments, allowing untrusted, high-risk vendors, such as Huawei, into any part of the network makes critical systems vulnerable to disruption, manipulation, and espionage. It puts sensitive government, commercial, and personal information at risk. The U.S.

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						government supports and promotes the Prague Proposals as a framework for regulatory best practices for securing 5G networks. Link to the Prague Proposals: https://www.vlada.cz/en/media-centrum/aktualne/prague-5gsecurity-conference-announced-series-of-recommendations-the-prague-proposals-173422
5G ecosystem development						
Question 13. What solutions have been and will be applied to promote digital transformation (ie. Digital Government, Digital Economy,		In January 2021, IMDA launched the 5G Innovation Programme to accelerate adoption and commercialisation of 5G solutions, to build on the earlier efforts to trial 5G	Viet Nam adopted national digital transformation program (june 2020) with many solotion has been applied to promote digtal transformation (decision 749/QD-TTg)	To promote digital transformation of government, the government has supported the expansion of high-speed Internet network to reach every village in the country so that everyone can have	MIC conducts several demonstration projects on and 5G/Local 5G to facilitate the introduction of 5G/local 5G.	Please refer to the strategies referenced in the response to Question 6.

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Digital Society ...) in your country ?		use cases. The fund will support enterprises' efforts to adopt 5G solutions to address sector challenges or enterprise level needs. The fund will also support solution providers and technology providers commercialising 5G solutions, to help make the benefits of 5G more accessible to more companies, including SMEs.		access to government information, programs and services online. Not only that, Digital Government Development Agency (Public Organization) or DGA created draft digital government plan 2020 – 2022 with the aim of enhancing government agencies' operations by harnessing the power of digital technology, creating government digital platforms to deliver better services to citizens and supporting open government data initiatives. Thailand, in addition, set out standard for open government data, encourage government agencies to open their data via website data.go.th,		

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				support data linking between those agencies and the use of digital ID, and develop portal that offers a training centre for government workers. The government has also supported the use of its wallet application called Pao Tang app, where citizens are able to receive financial support from it as part of cash handout and cash rebate schemes.		
Question 14. What 5G use cases do you see as benefiting the most from 5G ?Also, if there is a use case or model country that your country is referring to as a country that is currently leading the 5G development,		Each use case has its own merits.	under study. We are working with Qualcomm and GSMA to find out	5G use cases in a wide range of industries include automotive, manufacturing, media and entertainment, agriculture, energy and utilities, logistics, and healthcare will benefit the country greatly, and Thailand give great importance on	There are many use cases which benefits from 5G such as: disaster prevention and management, remote medicine, use in agriculture and dairy and livestock industry, smart factory(controlling IoT sensors, surveillance, etc.,) and use in construction sites(remote control	The U.S. government defers to the private sector to make their own determinations regarding the relative benefits of 5G use cases.

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please list it. Also, please describe the reason or background for choosing such case or country.				agriculture, healthcare and manufacturing. As Thailand is one of the leading countries for producing agricultural commodities, use case of combination of 5G, image recognition, satellite remote sensing, and big data is seen as one of the most practical use cases that will contribute to the growth of economy. There are many countries that do smart farming. For example, China, the world's large producer in agriculture and IoT market, has launched smart farming that allows the automated operation of unmanned machines. Thus, it is better to study from the country that has experiences in smart farming in big scale.	of construction machinery etc.,) etc.,.	

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Obstacles to 5G						
Question 15. Which of the following issues you think are the challenges need to resolve in order to promote 5G ecosystem?		☒ Utilization of backbone NETWORK ☒ 5G platform construction ☒ Gap between future image and reality for 5G ecosystem ☒ Securing budget ☒ Security measures ☒ Fostering 5G experts	☒ Utilization of backbone NETWORK ☒ 5G platform construction	☒ Utilization of backbone NETWORK ☒ 5G platform construction ☒ Latent digital division between urban and rural areas ☒ Security measures ☒ Fostering 5G experts	☒ Utilization of backbone NETWORK ☒ 5G platform construction	☒ Latent digital division between urban and rural areas ☒ Security measures
Initiatives on 5G						
Question 16. Do you have any proposal or initiatives on how to promote the development of 5G in ASEAN?		Raising Awareness of 5G development in ASEAN.	It could be great if we could establish a 5G ecosystem task force which help AMS to promote the development of 5G in ASEAN as well as promote ASEAN activities in regional and global forum for 5G development.	Countries in ASEAN should share successful stories in 5G use cases or policies so that ASEAN can come up with practical plan in 5G development.	Japan would like to support the development of 5G in ASEAN by sharing Japan's knowledge and experience. Also Japanese 5G model promotes Open Radio Access Network (O-RAN) and virtualized Radio Access Network (v-RAN), in construction of 5G network. This	Please refer to the strategies referenced in the response to Question 6, as well as to the forthcoming U.S. presentations during the upcoming ASEAN Conference on 5G Development.

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					enables multi-vendor deployments by using the equipment based on O-RAN and makes operators' procurement more flexible	

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