

**HUAWEI's RESPONSES TO IMDA SINGAPORE SECOND
PUBLIC CONSULTATION ON**

5G MOBILE SERVICES AND NETWORKS

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For the attention of:

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About Huawei

Huawei is a leading global provider of information and communications technology (ICT) infrastructure and smart devices. With integrated solutions across four key domains – telecom networks, IT, smart devices, and cloud services – we are committed to bringing digital to every person, home and organization for a fully connected, intelligent world.

Huawei's end-to-end portfolio of products, solutions and services are both competitive and secure. Through open collaboration with ecosystem partners, we create lasting value for our customers, working to empower people, enrich home life, and inspire innovation in organizations of all shapes and sizes.

At Huawei, innovation focuses on customer needs. We invest heavily in basic research, concentrating on technological breakthroughs that drive the world forward. We have more than 180,000 employees, and we operate in more than 170 countries and regions. Founded in 1987, Huawei is a private company fully owned by its employees.

About Huawei 5G

Since its 5G research started in 2009, Huawei has submitted 18000 proposals to 3GPP. Huawei has claimed 2570 5G patents in the essential category, making up the highest proportion of above 20% among all vendors. With the largest investment in standards, the broadest domains of research, and the greatest number of patents, Huawei took the least time to convert standards to products.

From 2009 when its 5G research was started to 2019, Huawei has accumulatively invested more than USD 4 billion on 5G R&D. More than 10000 persons have been poured into 5G network research (not including terminals).

Till June 2019, Huawei has gained over 50 5G commercial contracts and shipped over 150,000 5G base stations.

For more information, please visit Huawei online at <https://www.huawei.com/en/about-huawei>

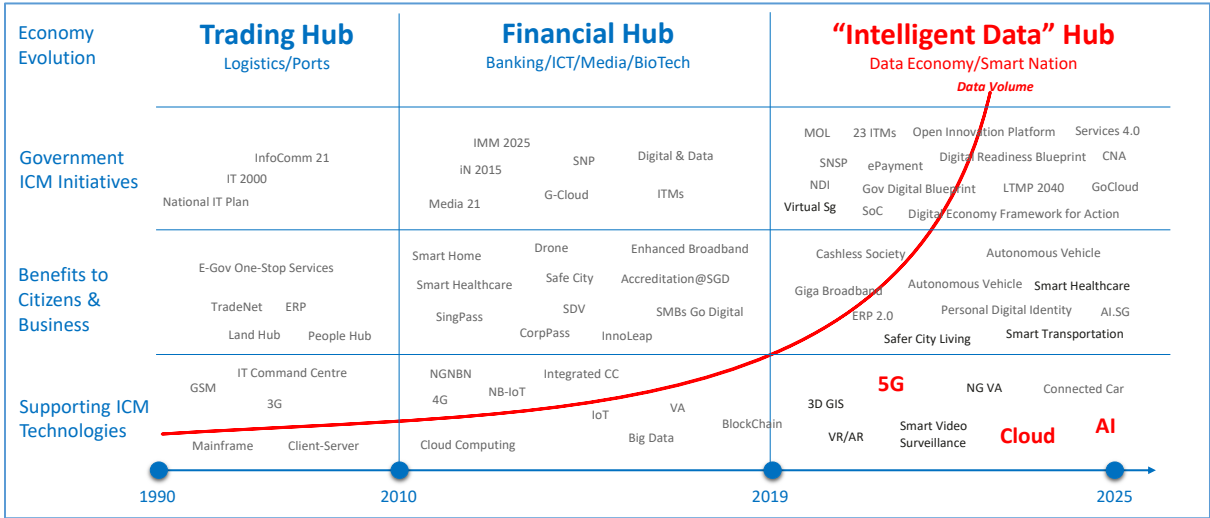
Question 1: IMDA would like to seek the industry’s views on skills requirements and the potential job demands in the future of networks and next generation of application/use-cases with 5G technology.

Huawei’s Response:

Singapore has always been seen by the world as a country in the forefront of utilising Infocommunication and Media (ICM) Technology to drive Singapore’s economic growth and create the friendly and efficient business environment to attract foreign investment and transform Singapore into a regional Services Hubs in the world.

The diagram below is the bird’s eye view of Singapore ICM development and landscape with government ICM initiatives, benefit programmes, projects created for the citizens and business, as well as the ICM technologies supporting the initiatives.

In the “Intelligent Data” Hub era, key technologies that are critical for the success of the various national initiatives include 5G, Cloud, AI and many others. 5G is the next generation telecommunication network for connectivity; and is also the key technology to drive industry transformation. Huawei is the leading global provider of ICT Infrastructure and Smart Devices, we are the leading 5G technology provider in the world and can help Singapore to speed up the industry digital transformation to realise the Smart Nation vision.



Singapore ICM Progress and Development Landscape

5G is expected to play a key role to enable and strengthen Singapore’s Digital Economy and hence Smart Nation aspirations. 5G will enhance Singapore’s reputation as a leading Information & Communications Technology (ICT) hub, providing enterprises with new competitive edges to drive economic growth.

According to IHS Markit ^[1], from 2020 to 2035, the total contribution of 5G to real global GDP will be equivalent to an economy the size of India (the seventh largest economy in the world). In 2035, 5G technologies are expected to generate US\$12.3 trillion of global economic output across multiple industry sectors from transport to manufacturing to healthcare.

The shift to next generation 5G will drive new growth in Singapore ICT job markets, driven by two key skill change drivers:

i) 5G Infrastructure Deployment & Operation

5G ushers in many new and revolutionary communication technologies as well as latest computing and information innovations for efficient infrastructure build and operation. Therefore, current telecom operator and contractor workforce not only has to upskill but also to broaden their knowledge and traverse across traditionally solid skill domains in order to be ready for 5G.

ii) 5G Digital Transformation

5G technology is the key enabler for digital transformation of vertical industries. We believe 5G will give rise to new emerging job roles within enterprises and vertical industries to support the application of 5G technologies as well as 5G-led digital transformation. These roles will require overlapping expertise between 5G and respective vertical domains as well as good understanding of technology and business.

With regards to workforce planning and talent development towards 5G, Huawei recommends to focus on the following skillsets:

- 5G New Radio (NR)
- Software
- Big data + AI
- Cloud computing
- Cyber Security
- Internet of Things (IoT)
- Industrial digital service design
- Industrial business process digitalization

^[1] IHS Markit, The 5G economy: How 5G technology will contribute to the global economy, January 2017

Question 2: IMDA would like to seek views on:

- i) The types of innovative use-cases that could capitalise and further enhance Singapore's competitive advantages, trigger new growth potential and/or strengthen Singapore's existing strategic pillars; and
- ii) Areas of government support that the industry require in order to enable innovation and development in 5G.

Huawei's Response:

- i) To remain as a competitive business hub in the region, Singapore has been embarking on a few national level initiatives:
 - **National Infrastructure** – 5G could be the key technology component to form national infrastructure, which will enable the whole industry digitalization for more productivity, higher efficiency, stronger competence, lower labour dependence and greater use of local talents advantages
 - **Safe City** – A City needs to be safe to provide the attractive environment for businesses. Singapore like many cities in the world has put this as a priority to create a stable, safe and friendly environment to support the business growth.
 - **Artificial Intelligence (AI)** – AI is Singapore national priority. AI has the potential to be applied to a variety of industries and use cases. With much to gain, Singapore is looking to build local capabilities and develop and deploy AI solutions to transform existing business sectors including transportation, logistics, safe city, healthcare, tourism, etc. Combining AI and 5G will provide the industry digital transformation with best connectivity with the needed intelligence.

These initiatives be it mega projects of national infrastructure, AI or Safe city, all required the 5G connectivity support. In our view, following are examples of recommended 5G innovative use-cases that could well fit into Singapore's strategic ICT pillars:

- **Smart Transportation** – Smart airport, smart rail, smart sea port, autonomous car and drones, etc.
- **Smart Logistic** – Truck platooning, tele-operated driving, autonomous delivery vehicles, etc.
- **Safe City** – Intelligent Operation Centre (IOC), smart campus, video analytic for public safety, etc.
- **Smart Manufacturing** – Industry 4.0 applications
- **Smart Healthcare** – Elderly care, remote diagnosis, smart helmet, etc.
- **Smart Tourism / Education** – Virtual reality/augmented reality
- **Enhanced Mobile Broadband** – Cloud X services

Huawei has identified top 10 applications to fully harness the versatile capabilities of 5G based on our understandings and insights of global markets. These 10 use cases are Cloud Virtual and Augmented Reality (VR/AR), Connected Automotive, Smart Manufacturing, Connected Energy, Wireless eHealth, Wireless Home Entertainment, Connected Drones, Social Networks, Personal AI Assistance, and Smart City. Huawei can work with IMDA and industry partners to incubate the localized use cases in alignment with Singapore strategic pillars.

ii) Government Support

Practical and timely deployment of policy as well as strong government support is vital to help clear the path for 5G. Huawei encourages the Singapore government to look into the following areas to facilitate 5G innovation and development:

- **Spectrum**
 - Timely assignment of C-Band spectrum to support 5G network rollout.
 - Reasonable spectrum price setting to avoid driving up cost of 5G services.
- **Ecosystem Development**
 - Subsidy and research fund support for 5G related innovations.
 - Development of 5G Incubation programs to grow local Start-ups and SMEs.
 - Bridging/connecting Singapore and other leading countries and areas 5G Ecosystem, to share the talent resources and innovations, to speed up 5G industrialization and capitalization
- **Policies**
 - Friendly policies for 5G ecosystem development such as incentive for MNOs to speed up 5G network rollout and industrial innovative 5G use cases development.
 - Government incentives to support 5G Infrastructure rollout such as sharing of public facilities, facilitate easier site acquisition and access, etc.
 - Promote joint and common 5G related policies among Government Ministries.
 - Promote industry standards for variety of 5G applications.
- **Talent Development**
 - Define talent skills framework
 - Training and talent development program for industry verticals.
 - Setup joint 5G certification with industry players
 - Collaborate with 5G vendors and industry players to offer 5G training, developing, test and verification environments and facilities

Question 3: IMDA would like to seek views and comments on the suitable technical parameters, including the reasonable amount of guard band needed to reduce potential interference between IMT and FSS use in the 3.5 GHz band.

Huawei's Response:

In general, the required size of guard band between the 5G IMT and FSS systems is related to 5G spurious emission level, performance of band pass filter retrofitted in the satellite receivers, and degree of spatial separation in the field. Examples of methodology to assess the potential interference between IMT and FSS use in the 3.5 GHz band can be found in ITU Report ITU-R S.2368.

It is theoretically feasible to reduce the guard band from 100MHz. In addition, it could be feasible to consider freeing up a portion of guard band for "restricted" use basis, where deployments can be initially limited to indoors and underground. Nevertheless, detailed analysis is required, based on actual deployed FSS receiver specifications and geographical distribution in Singapore. Neighboring countries are planning to conduct the C-band field trial to determine the technical and regulatory conditions for 5G usage in co-existence with satellite. And guard band is one of the conditions currently being studied.

Huawei welcomes IMDA's consideration of conducting similar exercise to better understand the guard band requirement between the 5G IMT and FSS systems based on Singapore's environment and actual spectrum use scenario. However, this should not delay the planned 5G spectrum releasing in Singapore.

Question 4: IMDA would like to seek views and comments on the following:

- i) Whether the industry agrees with the timelines on the expected availability of the next wave of 5G spectrum; and
- ii) Whether current deployments in the 2.5 GHz FDD spectrum band (based on 3GPP Band 7) and in the 2.5 GHz TDD spectrum band (based on 3GPP Band 38), should be refarmed to 3GPP Band 41 for future 5G services in Singapore, and the views on the associated cost and challenges.

Huawei's Response:

Huawei fully supports IMDA effort to make more spectrum to be available for 5G.

- i) For frequency bands below 1GHz, Huawei considers the already-auctioned 700MHz as the most ideal carrier for 5G IoT services. The European Commission has identified 700MHz as the 5G pioneering band. 6 member states including Denmark, Finland, France, Germany, Italy, Sweden have completed 700MHz assignment while the remaining countries are expected to complete the assignment by year 2020. Major chipset vendors will start supporting 5G NR at 700MHz from Q3 2019. Considering mature 700MHz ecosystem for 5G, Huawei

welcomes IMDA's consideration to permit operators to rollout 5G services as soon as the spectrum becomes available.

L-band is harmonized band from WRC-15, and 3GPP has specified L-band in Rel-15. ITU-R and the Regional Groups are working on the regulatory and technical conditions for the use of band. As this frequency band is adjacent to mobile satellite services in Singapore, Huawei encourages IMDA to commence on regulation planning for the L-band for IMT early.

As for 2.1GHz, the feasibility to reform to 5G depends on 3G and 4G traffic and service trend.

The frequency band 4800-4990 MHz has a potential for Regional harmonized 5G band (e.g. APAC and CIS) in the mid-term, as complementary 5G band in sub-6GHz spectrum. 3GPP has specified 5G NR band n79 4400-5000 MHz in Rel-15, and China and Japan are developing IMT/5G on portions of this frequency band. Usage of this band for IMT/5G could benefit from the existing eco-system developments and the economics of scale driven by the region. Considering this frequency is currently occupied by fixed service, Huawei suggests IMDA to commence on regulation planning on 4.5GHz for next wave 5G usage.

- ii) There is growing interest in APT region for 5G using the 2.5 GHz Band 41 band, however, this is limited to countries where 2.5 GHz FDD and 2.5GHz TDD have not been deployed or minimally deployed. In Singapore, 2.5GHz FDD spectrum (3GPP Band 7) is extensively deployed in existing operators' LTE network. Therefore, in Huawei's view, it is challenging to reform to 3GPP Band 41 for 5G services in near future considering the associated complexity and cost.

Question 5: IMDA would like to seek views, comments and suggestions on:

- i) Whether Singapore should have two nationwide networks as a start given the considerations and trade-offs;
- ii) The proposed 3.5 GHz lot sizes and spectrum packages;
- iii) Whether 5G equipment would be able to support 3.5 GHz bandwidths in multiples of 50 MHz;
- iv) The value, if any, in assigning the remaining 50 MHz restricted 3.5 GHz spectrum in the same assignment exercise as the unrestricted lots;
- v) The proposed mmWave lot sizes and preferred band plan option; and
- vi) The rank order preference of the 3.5 GHz spectrum package and mmWave lot combinations.

Huawei's Response:

- i) Huawei believes a minimum of two nationwide networks is required to drive long term healthy development of 5G industry and market in Singapore. Two-nationwide-networks is essential requirement to ensure basic resiliency for 5G services. With minimum of two 5G networks, positive competition ensures continuous investment and innovation amongst the MNOs.
- ii) For 3.5GHz, Huawei suggests IMDA to consider assigning the left most restricted spectrum in addition to the 100MHz+50MHz spectrum. The left most restricted 50MHz can be paired with the Lot B unrestricted 50MHz as a 100MHz spectrum package with total bandwidth equivalent to Lot A.
- iii) Huawei 5G equipment is capable of supporting 3.5 GHz bandwidths in multiples of 50 MHz within single unit of AAS.
- iv) Huawei sees the benefit of allocating the left most restricted 50MHz spectrum at this juncture. By pairing the left most restricted 50MHz with the Lot B unrestricted 50MHz, the 3.5GHz spectrum resource can be fully utilized for two nationwide 5G networks. While this arrangement result in non-contiguous spectrum assignment for Lot B, Huawei is confident that this would be easily addressed by technology development in the near term, using wide bandwidth radio equipment and 3GPP standard based intra-band non-contiguous carrier aggregation. Over time, with rapid advancement of technology and 3GPP standard, Huawei believes there is no significant difference between the suggested Lot A contiguous 100MHz and Lot B non-contiguous 50+50MHz spectrum assignment packages.
- v) Huawei welcomes IMDA's proposal to allocate the mmWave together with 3.5GHz. Huawei prefers mmWave band Option B as this band plan offers up to 6 equal blocks of 800MHz bandwidth across 26GHz and 28GHz as compared to 5 blocks of 800MHz in Option C.
- vi) Huawei does not have any preference regarding the 3.5 GHz spectrum package and mmWave lot combinations.

Question 6: IMDA would like to seek views, comments and suggestions on:

- i) The proposed network rollout and performance obligations to be imposed on the spectrum right holders;
- ii) The methodology and measurement criteria for the coverage obligation;
- iii) The network design and resilience challenges of 5G (in particular, enabling technologies, such as SDN, NFV and Cloud Computing that may fundamentally change how the network would be designed and deployed) and possible measures to address them, and whether there are other aspects that should be considered to enable trusted and resilient 5G network; and
- iv) The framework for the provision of 5G wholesale services.

Huawei's Response:

- i) Huawei believes a fair and reasonable network rollout and performance obligations will facilitate effective rollout of high quality 5G services to benefit end users.
- ii) Huawei suggests to consider SS-RSRP (secondary synchronization reference signal received power) as measurement criteria for the coverage obligation. SS-RSRP is defined as linear average over the power contributions (in Watts) of the resource elements which carry secondary synchronization signals. Based on standard drive test methodology, SS-RSRP can be measured using mature drive test tools in the market to achieve an independent assessment of 5G coverage.
- iii) Different measures should be taken to ensure network security and enhance network resilience in different phases of the 5G network lifecycle, including equipment selection, network deployment and acceptance, network operations, network maintenance and upgrade, and equipment retirement.

Additionally for 5G network resilience and service continuity, the IPDRR principles can also be applied. MNOs could consider to build the security operation capabilities for 5G network resilience, including high efficient vulnerability management, full-stack security protection, intelligent threat detection, automated security orchestration and open ecosystem. Security operations shall be embedded into the network service operation process to overcome the threats from ICT harmonization esp. for the new SDN and NFV networks. In such approaches, the O&M staff can also serve as Security Operation Staff in order to reduce the time to Identity, Protect, Detect, Respond and Recover with their experience and knowledge. The Security Operation allows an organization to collect data about security threats from multiple sources (cross domain, cross layer), make big data analytics through user plane, control plane and management plane, detect and respond to security events without human assistance. Such SOAR (Security Orchestration, Automation and Response) solution fully takes the

SDN/ NFV advantages and in return improves the efficiency of security response to support the 5G network E2E resilience.

And from the network design aspect, a proper implementation of threat mitigation measures is closely related to the development of Network Resilience Mechanisms, including the network redundancy, distributed management or secure backup are the main recommended measures. Redundancy of critical equipment in Radio Access, Network Core and transport network shall be at least introduced in terms of physical locations and buildings, hardware, software elements, and the deployment of NFVI by considering active/active and active/reserve configurations in the Data Center.

- iv) 5G extends the wholesale services domain much broader than the traditional voice and data service. Future 5G service may include but not limited to cloud (e.g. tradition storage, gaming, SD-WAN), V2X/IoT (latency sensitive), AR/VR, etc. For this reason, we believe 5G could give rise to new and robust types of wholesale/virtual network provider focusing on specific industry or vertical with specific service requirements.

New 5G capability such as network slicing would create fundamental changes to the provisioning and operation model of future 5G wholesale services. Therefore, Huawei suggests IMDA to consider review on existing wholesale service policy and framework with considerations on key areas including but not limiting to qualification/evaluation of wholesale service provider and obligation requirements, MNO/wholesale service provider partnership model, data privacy and security, etc.

Question 7: IMDA would like to seek views, comments and suggestions on the spectrum assignment framework, including:

- i) The proposed assignment approach;
- ii) The spectrum right duration of the 3.5 GHz package and mmWave lots;
- iii) The evaluation criteria, sub-criteria and weights to assess the proposals;
- iv) The assessment methodology, including evidence (documentary or otherwise) to evaluate the proposals; and
- v) The enforcement and/or audit mechanisms to ensure that applicants are able to deliver on their proposals.

Huawei's Response:

Huawei does not have any comment on IMDA's spectrum assignment framework.

Question 8: IMDA would like to seek views and comments on the trade-offs (particularly on resilience, 5G capabilities) and technical feasibility of the various levels of infrastructure sharing.

Huawei's Response:

5G is able to support various levels of infrastructure sharing as described in the IMDA consultation paper (Table 6). The frozen 3GPP Release 15 standard has specified support for 5G MOCN which facilitates sharing of radio equipment, radio resources and spectrum. Compared to site and passive antenna sharing, MOCN is an active RAN sharing mechanism that achieve higher cost savings. Compared to hosted/wholesale model, MOCN provides the advantage of maintaining independent core networks, hence capable of facilitating better 5G service differentiation among the sharing MNOs. By having distinct core networks, MOCN could also provide better network resiliency as compared to the hosted/wholesale model where any fault at the host core network may direct impact both the MNO and MVNOs' services.

Considering there is only limited bandwidth of C-band that can be made available initially before the full spectrum clearance and harmonization, Huawei recommends to consider 5G MOCN which is a more spectral efficient RAN infrastructure sharing model. Based on 3GPP standard, a 5G MOCN sharing network is capable of supporting key 5G capabilities including massive MIMO beamforming, network slicing and edge computing, though joint planning between sharing MNOs is typically required to enable these features.

Question 9: IMDA would like to seek views and comments on the following:

- i) The synchronisation approach for 5G TDD networks in a multi-operator environment for the 3.5 GHz and mmWave bands, specifically for the following:
 - a. Synchronised networks: the required frame alignment, compatible frame structures and BEM specifications for AAS and non-AAS base stations; and
 - b. Unsynchronised networks: the amount of guard band, geographical separation and BEM specifications for AAS and non-AAS base stations;
- ii) The adoption of other suitable mitigation measures to mitigate interference between unsynchronised networks; and
- iii) The need for IMDA to mandate a regulatory requirement for synchronisation across the 5G TDD networks or leave it to operators to co-ordinate their network deployment and parameters in order to reduce interference between networks.

Huawei's Response:

- i) Synchronisation and alignment of transmission frame between 5G TDD networks that operate in adjacent frequency blocks in 3.5GHz and mmWave

bands is the most efficient way to avoid interference between the networks without requiring additional mitigation techniques. Huawei recommends that MNOs deploy a common frame structure for 5G, i.e. downlink/uplink slot ratio of 4:1, 2.5ms switching period frame structure (DDDSU) and special slot format 10:2:2. Currently the 4:1 DL/UL slot ratio is the preferred 5G TDD deployment mode for major operators such as Korea, Hong Kong, Switzerland, Finland, Spain, and Kuwait.

- a. For a fully synchronised network, there is no additional BEM requirements on the 5G AAS and non-AAS base stations as long as they comply with the basic unwanted emission specifications as specified in 3GPP TS38.104 Chapter 6.
 - b. Unsynchronised network is susceptible to interference from out-of-band and spurious emission, resulting in severe degradation of 5G radio receiver sensitivity and performance. While there are few interference mitigation methods including customized AAS base station and filter solution, large guard band as well as geographical isolation design; all of these involve significant increase in network deployment cost and complexity.
- ii) For the above-mentioned challenge of unsynchronised 5G TDD networks, Huawei recommends IMDA to mandate for synchronized operation of 5G TDD networks among MNOs.
 - iii) To facilitate effective coordination amongst the MNOs and cross border synchronisation, Huawei suggests IMDA to consider specifying a common frame structure as prerequisite requirement for 5G TDD network deployment.

Question 10: IMDA would like to seek views and comments on the following:

- i) The interest from industry players to leverage 5G spectrum or other mobile spectrum bands for fixed-wireless services that support mobile connectivity; and
- ii) The policies (e.g., spectrum allocation, numbering) that should be considered to facilitate such use-cases.

Huawei's Response:

- i) Considering high fiber broadband service penetration and nationwide availability of fiber infrastructure in Singapore, Huawei agrees with IMDA's view that 5G fixed wireless access would not be the main use case for last mile fixed broadband access. Nevertheless, Huawei welcomes IMDA's proposal allowing MNOs to use 5G spectrum rights to provide other value added services including fixed-wireless service in addition to the primary and intended 5G mobile service.
- ii) Huawei believes that existing framework and policy would already be adequate to support fixed wireless service considering this is only a niche 5G use case in the Singapore market.